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on Boeing's 787



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Battle hardened
at retirement



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**Next
Month:
Airborne
Early
Warning**

From the Editor

TAKING LIFE easy on March 2, my peace was broken by the familiar chime from the computers signalling the arrival of another email. Nothing unusual about that, except this one contained images of an F-117 Knighthawk: the original stealth fighter developed in the mid-1970s. The images had been taken two days previously by AIR International's Dan Stijovich who was, by chance, in the right place at the right time, and was able to photograph the one-of-a-kind black jet at 200ft above ground level in California's Panamint Valley. Since its retirement from active duty service in 2008, there have been various sightings of F-117s flying in central Nevada; this time the FY1984 jet seen by Dan was low and in his face! We provide a four-page report of the event.

In this issue, we also have the first of a two-part feature on the Tornado GR4 and its retirement from Royal Air Force service; we detail Boeing's Loyal Wingman air vehicle, shed light on Spanish plans to introduce the MQ-9 unmanned air vehicle into military service, provide show reports from Aero India at Bengaluru and Avalon, Australia, and review the gargantuan FY2020 budget requests by the US Air Force, Army, Marine Corps and Navy.

As if that wasn't enough, we also have features on the Leonardo

AW609 tiltrotor, RAF C-130J operations, GE Aviation's XA100 future fighter engine, the first report of flight operations on board HMS Queen Elizabeth, and offer a look at the Proteus, a fascinating air vehicle designed and operated by Scaled Composites at Mojave, California.

You can read all these stories in this issue, along with an analysis of Boeing's 787 Dreamliner – across ten pages providing details of the programme, fleet, operators and ongoing improvement programmes, one of our main themes this month.

AIR International's May 2019 issue will include coverage of the latest airborne early warning aircraft and an overview of BAE Systems' portfolio of air systems: Hawk, Taranis and Tempest. The blistering May issue will be on sale in the UK and around the globe from April 25.

Mark Ayton

Mark Ayton, Editor

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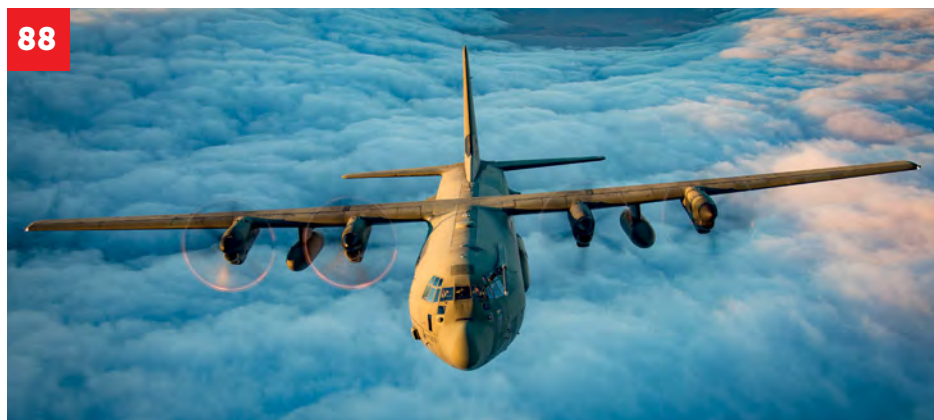
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Growlers for Finland?



Finland has received US government approval to purchase the Boeing EA-18G Growler, together with the F/A-18 Super Hornet if selected for its HX Fighter Replacement programme. *Boeing*

The US government announced on February 18, 2019, that it has granted approval for the sale of an undisclosed number of Boeing EA-18G airborne electronic attack aircraft to Finland.

The approval came in response to a request from the Finnish Ministry of Defence for the possible sale of F/A-18 Super Hornets and Growlers as part of the Nordic country's HX fighter replacement programme. However, a decision has not yet been made.

In response to the announcement, Boeing's Vice President of F/A-18 and EA-18G programmes, Dan Gillian, said: "All

strike fighter aircraft rely on Growler escort to increase survivability during high-threat missions. The combination of the Super Hornet Block III and Growler would provide Finland with superior technological capability particularly suited to the country's HX mission requirements."

Finland becomes only the second foreign country to gain approval for Growler. The first, Australia, currently operates 11 aircraft from RAAF Base Amberley in Queensland. A twelfth aircraft was lost in a take-off incident at Nellis Air Force Base in the United States in January 2018 and a decision on whether to replace the aircraft is yet to be announced. *Nigel Pittaway*

Boeing 777X roll out



This photo of the first Boeing 777-9 flight test aircraft rolling out shows the new jet's folding wingtips. *Boeing*

Boeing rolled out the first flight test 777-9 at Everett in mid-March. The aircraft, N7779XW, is due to undertake its first flight this year before the first customer delivery to the initial operator, Lufthansa, in 2020 following flight and certification testing. The General

Electric GE9X-powered aircraft will seat 400-425 passengers and have 7,525 nautical miles (13,490km) range. A second 777X family member, the 777-8, will seat 350-375 passengers and offer 8,690 nautical miles (16,090km) range.

Mark Broadbent

S-92: new variant

Sikorsky announced at Heli-Expo on March 5, 2019, that it will introduce modifications to its popular S-92 helicopter, available either as a retro-fit to existing helicopters or for newly-produced aircraft.

After modification, existing helicopters will be known as S-92A+ and new-build examples, S-92B+.

The company says the changes will increase

commonality between the offshore, SAR and utility configurations of the S-92 with the two new variants sharing an almost identical configuration following modification.

The S-92B will, however, feature enlarged cabin windows and Sikorsky says it has plans to introduce a common cabin door, suitable for offshore and SAR operations. *Nigel Pittaway*

Prowler bows out



EA-6B Prowlers BuNo 162230/CY02 and 162228/CY04 assigned to Marine Tactical Electronic Warfare Squadron 2 fly off the coast of North Carolina, on February 28, 2019, one of the squadron's last flights prior to its deactivation on March 8, 2019. *Lance Cpl Liam Higgins/US Marine Corps*

The last US Marine Corps unit to operate the Grumman EA-6B Prowler, Marine Tactical Electronic Warfare Squadron 2 (VMA-Q) 'Death Jesters', ceased its colours in a ceremony at Marine Corps Air Station Cherry Point, North Carolina, on March 8, 2019. Only two jets remained in service with the squadron at the time of the ceremony, BuNo 162228/CY04 and BuNo 162230/CY02, the latter painted in a high visibility colour scheme. The two aircraft were flown out of Cherry Point, one on March 12 to a museum in Texas and one on March 14 to the National Air and Space Museum at Dulles, Virginia. VMAQ-2 returned to Cherry Point in November from its final deployment to Al Udeid Air Base, Qatar, in the US Central Command area of responsibility.

The US Navy stopped flying the Prowler, after 45 years, in 2015. The US Marine Corps held on to its Prowlers longer. First to go was VMAQ-1 'Banshees' on April 29, 2016, VMAQ-4 'Seahawks' on June 2, 2017 and VMAQ-3 'Moondogs' on May 11, 2018.

Cherry Point-based VMAQ squadrons deployed EA-6Bs to

numerous bases and aircraft carriers over their service, providing electronic jamming and attack in support of joint forces, including participation in combat operations in Afghanistan, Bosnia, Iraq, Kosovo, Kuwait, Libya, Serbia and Syria.

The Marine Corps is not fielding a direct replacement for the EA-6B, instead relying on other platforms like the F-35B, organic electronic warfare systems such as the Intrepid Tiger pod, unmanned air vehicles, and the Navy's EA-18G Growler-equipped electronic attack squadrons.

The Prowler entered combat with the US Navy's Tactical Electronic Warfare Squadron 132 (VAQ-132) during 1972 over North Vietnam and served in numerous conflicts and crises since, most notably Operations El Dorado Canyon, Desert Storm, Southern Watch, Allied Force, Desert Fox, Enduring Freedom and Iraqi Freedom. Electronic Attack Squadron 134 (VAQ-134) 'Garudas' was the last to go on June 30.

Like 14 other Navy squadrons it converted to the EA-18G Growler.

Rick Burgess

Electric commuter aircraft

The UK aerospace start-up company Faradair has announced plans to produce an 18-seat hybrid electric passenger aircraft, the Bio-Electric Hybrid Aircraft (BEHA) M1H, which it plans to certify for operations by 2025.

The BEHA M1H will use a hybrid propulsion system combining electric motors with a turboprop engine and Faradair's patented Triple Box-Wing configuration to generate high lift. The aircraft has twin contra-rotating propfans within a vectored thrust and an acoustic reduction duct that Faradair says improves efficiency and reduces noise to a target of 60dB at take-off.

Faradair said the BEHA M1H's configuration will lead to, "lower operating costs, lower emissions and increased safety redundancy. The aircraft will use existing battery technology for emergency power and ground operations." The aircraft will be capable of carrying 18 passengers or three LD3 cargo containers up to 5,000kg (11,023lb) and will be able to change from

cargo to passenger configuration, or vice versa, in 15 minutes.

Faradair Managing Director Neil Cloughley said: "We have always believed in the opportunity of hybrid propulsion to help reduce noise and operating costs in a specifically designed airframe optimised for regional flight capability. The BEHA M1H will allow operators the ability to provide viable air transport services including scheduled commuting flights, flight training and charter by day and the ability to use the quiet flight characteristics and payload capability for cargo operations at night.

"This opens market opportunities not served by existing aircraft, due to the lower noise signature and load capability. Our hybrid propulsion system mixes the proven capability of existing turboprop engines, which could be run on biofuel if desired, with the fuel saving and increased safety opportunity of additional electric propulsion."

The BEHA M1H is the latest addition to Faradair's portfolio,



Artist's impression of the 18-seat BEHA M1H. Faradair

the company having previously announced a hybrid-engine variant called the BEHA-H1, an all-electric BEHA-E1 and the BEHA M1 military variant (the company has also offered an unmanned version of the BEHA M1 called the M1-AT).

The company said: "The BEHA is a traditional aircraft, certifiable to existing [EASA] Part 23 standards, able to operate from existing

airfields but more importantly, able to operate from runways of 300m or less of any surface and be able to integrate within existing air networks."

Faradair said it is in talks with potential civilian and non-civilian customers. The company will begin building the first demonstration prototype of the aircraft later this year and intends to begin flight trials by 2022. Mark Broadbent

737 MAX grounded

The Boeing 737 MAX is subject to a worldwide grounding following the March 10 crash involving Ethiopian Airlines Flight ET 302 after departure from Addis Ababa.

A US Federal Aviation Administration (FAA) statement said: "The grounding will remain in effect pending further investigation, including examination of information from the aircraft's flight data recorders and cockpit voice recorders."

The recorders were recovered from the crash site and were received by the Bureau of Enquiry and Analysis for Civil Aviation Safety in France on March 14. The US National Transportation Safety Board and Ethiopian authorities sent investigators to assist.

The grounding affects all 737 MAX 8 and 737 MAX 9 aircraft in service as of March 14, a total of 371 aircraft. The accident in Ethiopia

was the second loss of a 737 MAX 8 within six months, after Lion Air Boeing 737 MAX 8 operating Flight 610 crashed off Indonesia in October 2018. The accidents claimed a total of 346 lives.

A Boeing statement said: "We are supporting this proactive step out of an abundance of caution. Safety is a core value at Boeing. We are doing everything we can to understand the cause of the accidents."

On March 11, two days before the grounding order, the FAA said Boeing was introducing a software update to the 737 MAX's Manoeuvring Characteristics Augmentation System. These updates, Boeing said in a statement, limit "stabiliser trim commands in response to an erroneous angle of attack reading" and "limit the stabiliser command in order to retain elevator authority". Mark Broadbent

Schweizer Luftwaffe PC-24



The Schweizer Luftwaffe (Swiss Air Force) announced on February 18, 2019, that it has taken delivery of a Pilatus PC-24 executive jet, for operation by the Confederation Air Transport Service and Lufttransportdienst des Bundes. Aircraft T-786 (msn 21) was handed over on the above date at a ceremony in Berne, in the presence of Pilatus' Chairman of the Board of Directors, Oskar Schwenk and Bernhard Müller, Commander of the Schweizer Luftwaffe. The aircraft was originally ordered in July 2014 and will be based at Bern-Belp, primarily for use on operations within Europe.

Zambian Spartan



Leonardo C-27J Spartan AF 002 in full Zambian Air Force colours at Turin-Caselle airport, Italy, on March 15, 2018 during a test flight. The aircraft made its first flight on July 17, 2018, without Zambian Air Force titles and insignia. In September 2015 Alenia Aermacchi (now Leonardo) announced an undisclosed African air force had ordered two C-27J Spartans. In December 2017 Zambian Air Force Deputy Commander, Major General David Muma confirmed the deal. The second Zambian C-27J, AF 003, made its maiden flight on December 27, 2018.

Marco Rossi.

THEY NEVER really went away. The Lockheed Martin F-117 Nighthawk stealth fighters were sleeping, in the hangars they had occupied in the early years of their operational career, at Tonopah Test Range Air Base, Nevada, near Groom Lake (the Area 51 beloved by films and television). The black jet – its skin is radar-absorbent material – went by many nicknames. As it was unstable in flight – it could only be flown because of computerised flight stabilisation – it became known as the Wobblin' Goblin, the latter being the name of an earlier stealth design that was never produced.

Congress had insisted on the preservation of the US Air Force F-117 fleet when it was withdrawn from active service in 2008. The National Defense Authorization Act of 2017 authorised the fleet to be demilitarised at a rate of four per year. Since then, there was no indication that F-117s were to be scrapped; indeed, the one pre-production aircraft that was

scrapped showed the process to be an expensive and difficult one, an environmental nightmare.

With its first-generation stealth technology still classified – the F-117 aircraft preserved at the Air Force Museum at Wright Patterson Air Force Base is a test aircraft built with standard materials – the aircraft could not be hauled off to the boneyard at Davis-Monthan Air Force Base near Tucson, Arizona. The Air Force might quietly truck them away, pry off their gold-dusted radar-reflective canopies, and bury them in the desert at night, despite fears that material contained in the low-observable coatings might seep into the ground water. Beauty is skin deep, but stealth is bad to the bone.

Since 2010, there have been multiple credible sightings and reports of single and two-ship F-117 flights, mainly operating in and around Nellis Air Force Base and Tonopah and, once, even refuelling from a KC-10A tanker. A fatal crash of

an unidentified US Air Force aircraft near Groom Lake, on September 5, 2017, may have been an F-117. The most recent F-117 photographs were taken in Panamint Valley, California.

Back in combat?

Yet it was a surprise when, in February, the well-respected Dutch aviation magazine *Scramble* reported on its website that in 2017 four F-117s had flown combat missions over Syria and Iraq during Operation Inherent Resolve. The aircraft were reportedly based at an undisclosed location in the Central Command area of responsibility. This usually means Al Udeid Air Base, Qatar, but could also be a base in Saudi Arabia, the United Arab Emirates or Kuwait. The report stated during this deployment at least one was forced to make an emergency landing while flying a mission.

Was this the F-117's last combat deployment? Maybe, but is not

surprising that the events were not publically disclosed; in the past two years, the Department of Defense has cut back its release of information, especially about combat operations.

The question remains: why were F-117s sent back into combat?

The Air Force had already flown a stealth fighter over Syria; the F-22 Raptor is laced with stealth technology of a more advanced nature than that used on the F-117. It has reportedly performed up to expectations. F-22 combat sorties have doubtlessly been studied by as many sensors as the Russians could forward deploy to their bases in Syria.

Whatever F-117s were tasked to do over Syria, it was likely something that F-22s either cannot do or do not want to do with the Russians watching.

The F-117 was designed to carry internally the 2,000lb EGBU-27 GPS/laser-guided hard and deeply buried target defeat (HDBTD) munition, a GBU-24 modified specifically for the F-117.



Return of the Wobblin' Goblin

David C Isby provides an oversight of the F-117 Nighthawk following its public reappearance in late February



During its operational service life with the active-duty Air Force, the F-117 Knighthawk was rarely seen at 200ft AGL, let alone caught on camera.



The pilot of F-117 84-0824 made at least two passes giving the 'shaka' gesture at the AIR International photographer.

All images Dan Stijovich



Heading home; the F-117 flanked on each wing tip by an F-16 from the Air National Guard Air Force Reserve Command Test Center based at Tucson Air National Guard Base.



Another F-117 armament option was the special purpose BLU-114/B sub-munition packed with large numbers of carbon graphite filaments. A number of sub-munitions contained within the bomb casing are dispensed over the intended target to produce non-lethal effects, shorting out electrical power distribution equipment with their filament payloads.

The F-22 Raptor, a specialist air dominance fighter, was designed to carry nothing internally larger than a 1,000lb bomb.

While the Scramble report stated the F-117s delivered GBU-39/B Small Diameter Bombs (a munition that had not been integrated on the F-117 at the time the type left active service), accurate and stealthy delivery of munitions, probably for HDBTD effects, is the most likely purpose behind an F-117 deployment. Whether they actually dropped weapons remains uncertain.

Maybe it was enough for the evil people that live in bunkers to know they were at risk of immediate and painful death and realised they

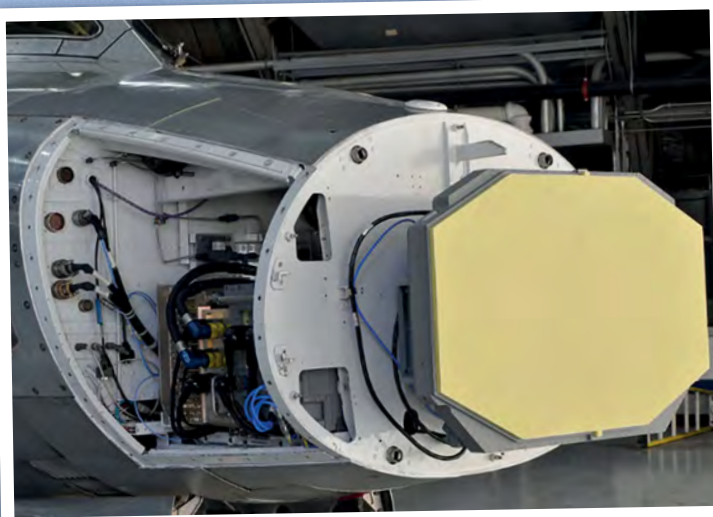
needed to go elsewhere to remain alive. When evil people leave their bunkers, they cannot bring along the secure landline communications they so rely on, just one way they become more vulnerable to a range of intelligence sources.

Another way to make them vulnerable is to short-out their existing communications by using BLU-114s, and then to intercept and monitor them as they subsequently come up on their backup circuits.

What really happened?

Why are some F-117s flying in the United States? Asking the Air Force does not help. The service stopped talking about the F-117 when it went out of service, except to say that the aircraft were being kept in Type 1000 flyable storage to meet the congressional requirement and that they were occasionally flown. It was estimated that about six were usually held in flight status, flown by Air Force and contractor (retired F-117) pilots.

There are many more potential uses for a small residual Nevada-based F-117 force. The most likely is



An AG-83 Scalable Agile Beam Radar fitted to Northrop Grumman's Sabreliner NA-265 testbed. The AG-83 provides greater target detection and tracking range with faster search and target acquisition, smaller target detection and multi-target tracking.

Northrop Grumman

supporting training and research and development efforts, developing counter-stealth tactics and sensors and seeing how these work.

The sighting of an F-117 flying north-to-south and south-to-north runs at 200ft through California's Panamint valley on February 26 and 27, with two F-16C fighters

assigned to the Air National Guard Air Force Reserve Command Test Center (AATC) makes more sense as a testing or tactical scenario than training for an operational mission profile. At the height of its operational utility in the 1990s, the F-117 bombed straight and level from high altitude.



This highly-cropped frame shows what looks to be a Lockheed Martin Legion pod fitted to one of the F-16s seen over the Panamint Valley.



Lockheed Martin's infographic of the Legion pod, a multi-function sensor system that includes the ASG-34 long-wave infrared sensor. *Lockheed Martin*



Wing tipped toward the camera affords a partial look-down view of the F-117's faceted fuselage surface configuration.

On the morning of February 26, an F-117, callsign LEHI 1, checked in with the low-level control agency for the area around Panamint Valley, the pilot advising his intent to work at 200ft above ground level in the valley before departing to the north, presumably returning to Tonopah.

That afternoon, F-117 serial number 84-0824, callsign LEHI 1 checked in with the control agency followed by two F-16Cs, callsign SHARK 1 and 2. High winds were blowing through Panamint from the south creating a resultant dust storm in effect. The F-117 pilot told the F-16 pilots of his concern caused by the amount of trash and hash at his altitude, and that it might curtail their ops.

The F-117 made two southbound runs before climbing to about 10,000ft and formed up with the two F-16s; one on either wing heading north. The F-16s returned to Edwards Air Force Base to the southwest, and the F-117 departed the area to the north, presumably to Tonopah.

On the morning of February 27, at approximately the same time

as the previous morning, an F-117 callsign LEHI 1 checked in with the control agency to the north, and two F-16s also checked in at a position 20 miles southeast of Naval Air Weapons Station China Lake; a point to the southwest of the valley.

Over a 40-minute period, the F-117 made multiple runs at 200ft above the valley floor, firstly flying from the north to the south and returning south to north, each one on a different track along the valley. At the conclusion of the operation the three aircraft returned to their respective home stations. The F-16s flying at 13,500ft made opposing runs at the F-117 on each and every run. During the afternoon operation the F-117, again departed to the north and the F-16s returned to their home at Tucson Air National Guard Base, Arizona.

It is plausible that this operation involved the F-117 simulating a stealthy air threat to test either the low-level detection capability of the F-16's radar or another on board sensor or to help develop tactics to detect such a threat.

At least one of the F-16s was fitted with a Legion Pod; a multi-function sensor system that includes the ASG-34 long-wave infrared sensor and a processor capable of high-fidelity detection and tracking of airborne targets seeking heat generated by the target aircraft's engine and aerodynamic heating of the airframe generated during flight. According to manufacturer Lockheed Martin, the Legion pod supports collaborative targeting operations in radar-denied environments.

Given the F-16s were aircraft assigned to the AATC, it's equally plausible that a radar system was under evaluation, perhaps the new Northrop Grumman APG-83 Scalable Agile Beam Radar, an active electronically scanned array system ordered by the US Air Force in May 2017. Northrop Grumman was awarded a \$243.8 million contract for 72 APG-83 units to upgrade 72 US Air National Guard F-16s to meet a US Northern Command Joint Emergent Operational Need for homeland defence. There have been classified cruise missile defence sensor programmes in the

black world since the 1980s, and the F-16s may have been testing something from this source.

In Syria and California, however, F-117s could also be flying to provide cover for black-world classified programmes that have not yet emerged. Letting air traffic control in the US or Russian radar operators in Syria assume a problematic radar or sensor return from an F-117 may help keep the identity of the actual source secure. Such black-world aircraft may well be unmanned (the absence of publicly identified programmes to provide new unmanned combat air vehicle capabilities has raised suspicion) and may be operated by intelligence services rather than the Air Force. Tonopah is also home to the Lockheed Martin RQ-170 high-altitude UAV, the so-called 'Beast of Kandahar', which emerged from the black world when the first example was seen at Kandahar in late 2007.

Basing RQ-170s and the not-totally-retired F-117s together may be a function of operational utility as well as the availability of secure facilities at Tonopah.



Level at 200ft above the valley floor, LEHI 1 makes one of multiple runs in Panamint Valley.



THE MAJOR news story at the 2019 Australian International Airshow at Avalon in late February was the unveiling of Boeing's Australian designed and developed Airpower Teaming System unmanned air vehicle.

A wooden mock-up of the air vehicle was unveiled in front of Australian Defence Minister Christopher Pyne, senior Royal Australian Air Force (RAAF) officers and Boeing officials. The Airpower Teaming System

is designed to operate alongside manned platforms in the Loyal Wingman role.

The concept has been developed by Boeing Defence Australia, in partnership with the RAAF and Australia's Defence Science and

Technology Group (DST Group) and other industry bodies, including BAE Systems Australia and Saab Australia. A prototype is currently under construction at an undisclosed location in Australia and expected to fly in 2020.

Loyal Wingman

Nigel Pittaway details the Boeing Loyal Wingman recently unveiled at Avalon

A selection of artist impressions of Loyal Wingman air vehicles showing the wing, stabiliser and fuselage forms.

All images Boeing





The Airpower Teaming System is being developed under the Australian Defence Force's Defence Project 6014 Phase 1 (Loyal Wingman Advanced Development Programme), although it is not yet an acquisition programme of record. Minister Pyne revealed that the Australian government has contributed AUD 40 million over four years to the continued development of the programme, which will see the construction of three prototype air vehicles - the minimum number required to adequately test the teaming concept. Boeing is also contributing funding to the programme, but the company declined to provide further details and would also not disclose whether the US government had invested in the concept.

Pyne said: "This will be Boeing's first unmanned aircraft designed and engineered in Australia and

represents the company's largest investment of its kind outside of the United States."

He added: "This is also the first [military] aircraft concept Australia has invested in since the Boomerang fighter in the Second World War, so it is a red-letter day." Despite the sentiment however, Pyne omitted to mention the locally-designed GAF Jindivik unmanned platform, which was successfully produced between the 1950s and the 1990s.

Firm details of the air vehicle's specification and performance were not forthcoming at the unveiling ceremony on February 27, 2019 and even the mock-up's exhaust nozzle was hidden from view. Boeing's Director of Phantom Works, Shane Arnott, said the aircraft is 38 feet (11.7m) long, will have a range of 2,000 nautical miles (3,700km) and be capable of fighter-like performance. It will also be fitted with onboard sensors to



enable it to perform intelligence, surveillance and reconnaissance and electronic warfare roles, but Arnott declined to provide any further details, including what engine the aircraft will have or what weapons (kinetic or otherwise) it will be capable of deploying.

The Airpower Teaming System will be offered to 'Five Eyes' (Australia, Canada, New Zealand, the United Kingdom and the US) and potentially represent a

significant export opportunity. It is a semi-autonomous multi-mission system, capable of being controlled either from a ground control station or escorting platform and, according to Arnott no modifications to the manned platforms are required, suggesting a high level of artificial intelligence. The concept will see one manned platform operating in conjunction with between five and six Loyal Wingmen.



As modern unmanned air vehicle designs go, Boeing's Loyal Wingman has an unusual, but graceful form featuring typical low-observability characteristics; an angular fuselage cross section, narrow air inlets, and cantered vertical stabilisers.



According to Boeing the Loyal Wingman air vehicle measures 38ft in length. Scaling this shot, the depth of the fuselage appears to be in the order of 6 to 7ft and the vertical stabilisers a little closer to 8ft when measured from the fuselage underside.

Nigerian Super Tucano contract finalised

Sierra Nevada Corporation (SNC) and Embraer have confirmed Nigeria's contract for 12 A-29 Super Tucano aircraft. The aircraft will be built at SNC's Jacksonville, Florida facility and modified in Centennial, Colorado. Work is expected to be completed in May 2024. The \$329 million contract was placed with SNC by the US Department of Defense (DoD) in November 2018 but confirmed by the two manufacturers in February this year. The initial contract amount covers the aircraft, but the Nigerian Air

Force will also get weapons and sensors under separate contracts – six of the aircraft will receive AAQ-22F sensors and laser designator turrets. On February 6 the DoD confirmed that Nigeria will be getting the Advanced Precision Kill Weapon System (APKWS), which upgrades 2.75 inch (70mm) rockets into laser-guided weapons. With Paveway II guided bombs, APKWS rockets, 0.50 calibre (12.7mm) ammunition and sensors, the total value of the Nigerian deal increases to \$593 million. *Guy Martin*

Belgian SF-260s celebrate 50 years

The SIAI-Marchetti (now Leonardo) SF-260 celebrates 50 years' service with Belgium's Air Force in 2019. A total of 45 of the Italian-built trainer were bought. The mixed fleet of 25 upgraded SF-260M+ and seven SF-260D aircraft are used by 5 Squadron at Beauvechain for basic pilot training and streaming

into fighters, transports or helicopters.

The SF-260 is also used by the Diablos Rouges (Red Devils) aerobatic team, formerly equipped with the Fouga CM170 Magister.

For the celebration, some of the Marchettis were seen in a commemorative colour scheme.



The tail of SF-260M+ ST-02 has received this commemorative paint scheme. *via Bob Fischer*



This camouflaged SF-260 seen at Florennes Air Base has since been painted in the modern grey colour scheme. *Bob Fischer*

Poland pledges €43 billion defence spend

Polish Minister of National Defence Mariusz Blaszczak has announced a Technical Modernization Plan (TMP) for updating Poland's armed forces up to 2026. In 2017 the nation was one of only eight NATO members to spend more than 2% of its gross domestic product (GDP) on defence and the plan continues that trend.

Aimed chiefly at strengthening Poland's defences on its eastern Russian-facing flank, the TMP includes many aviation related programmes. One of the main planks of the plan, the Harpia programme, calls for the acquisition of 32 fifth-generation multi-role aircraft to provide an anti-access, area-denial network-centric capability to work with other components of allied forces. Under the Kruk programme Poland will buy a modern attack helicopter. An initial tranche of three machines must be delivered before 2022 for crew training and the rest by 2035. Airbus Helicopters/Heli Invest

are offering the EC665 Tiger; Turkish Aerospace Industries and WSK PZL-Swidnik the T129, and Bell Helicopter and Boeing are promoting the AH-1Z and AH-64E in conjunction with the US government. Leonardo proposes the AW249 presently being developed for Italy's army.

Up to 200 UAVs of different sizes and capabilities, many of which will be optimised for operations in urban environments, are to be obtained under the Gryf and Wazka programmes. The Flame programme consolidates existing plans to purchase maritime patrol and intelligence, surveillance and reconnaissance aircraft.

The minister's announcement confirms Poland's commitment to continue to meet its fiscal responsibilities to NATO and to spend 2.5% of GDP on defence annually from 2030. Preparations are underway for the next TMP up to 2034.

American assistance to Cameroon halted

Following allegations of human rights violations, the United States is halting some of its military assistance to Cameroon. The measures announced by the US State Department on February 6 include the termination of a C-130 aircraft training programme and the upgrade of a Cessna aircraft for Cameroon's rapid intervention battalion. Also affected are the delivery of four Defender patrol boats and nine armoured vehicles. Cameroon will also no longer be eligible to join the

United States' State Partnership Program. The aid was intended to help Cameroon fight Boko Haram insurgents but was halted after authorities were accused of using the fight against Boko Haram to crack down on political opponents. Between 2012 and 2016 the US provided \$220 million in military aid to Cameroon, which included delivering two Cessna 208 Caravan intelligence, surveillance and reconnaissance aircraft to Cameroon's Air Force in May 2018. *Guy Martin*

CSIR's small gas turbine

South African technology innovation centre, the Council for Scientific and Industrial Research (CSIR), is developing a small gas turbine engine for stand-off weapons, gliders and unmanned aerial vehicles. The 220lb-thrust class engine has been under development for the last three years and is due to undergo its first compressor test in the first half of this year. The compressor design is scalable, meaning that engines in the 130lb to 330lb class can be developed with minor changes to the basic design – the largest compressor design could form the high-pressure core of a larger engine family. A shaft engine variant could also be developed to produce 100kW shaft horse power. The CSIR is funding development

itself at present but is offering the engine to industry partners for commercial use. It emphasises that the engine is ITAR-free (International Traffic in Arms Regulations), which is a significant feature as there are few micro jet engine manufacturers because small jet engines can be used in stand-off weapons.

The CSIR has previous experience with gas turbine development, having worked on the 143lb-rated APA350 engine in the early 1990s, and improved the Atar 09K50 in the 1980s. Together with the University of Stellenbosch, the CSIR led to Cape Aerospace Technologies building three small gas turbines producing 25, 55 and 85lb of thrust. These have been in production for several years.

Guy Martin

Dates for Swiss fighter trials announced

Switzerland has tried twice before to initiate a programme to replace its F/A-18 Hornet fighters, but on each occasion a national referendum has vetoed the acquisition on the grounds of cost.

Armasuisse announced the dates for the evaluations of the five candidates for the latest round of trials in the fighter replacement programme in February. Each of the five jets will undergo two weeks of flight tests and other examinations at Payerne Air Base between April and July.

First up, in calendar weeks 15 to 16, is Airbus with its Eurofighter, Boeing and its F/A-18E is next during weeks 17 and 18. Then comes Dassault in weeks 20 to 21 with the Rafale (the winner of the last competition). Lockheed Martin with the F-35A will visit for weeks 23 to 24 and finally Saab will take its Gripen E (the winner of the first competition) between weeks 24 and 25. The placing of each aircraft in the schedule has been determined by the alphabetical position of the manufacturer in the list of contenders.

Each candidate will be permitted to make a familiarization flight before performing a total of eight missions, one in darkness, using one or two aircraft during four days of flight operations.

Upon completion of the tests a second and final request for proposals will be issued to the manufacturers who will then be required to make their best and final offers in the spring of 2020. The government is expected to announce its choice in the second half of 2020, for consideration by parliament as part of the annual armaments programme for 2022. Deliveries must begin in 2025 and be completed by 2030.

Under the Air2030 programme, Switzerland has earmarked CHF 8 billion to pay for the replacement of its entire air defence system, including its ground-based missiles, F/A-18 Hornets and F-5E Tiger IIs, by 2030. The Schweizer Luftwaffe has a requirement for between 30 and 40 jets to be based at Payerne and Meiringen Air Bases.



Goalposts moved for F-35C IOC

The Commander, Naval Air Forces and the US Marine Corps Deputy Commandant for Aviation jointly announced that the F-35C Lightning II met all requirements and achieved Initial Operational Capability (IOC) on February 28. The declaration means that all three variants of the Joint Strike Fighter have now achieved IOC.

In order to declare IOC, the first operational squadron must be properly manned, trained and equipped to conduct assigned missions in support of fleet operations. This is defined as having at least 30% of its planned unit establishment of aircraft. The US Navy's first F-35C unit, Strike Fighter Squadron 147 (VFA-147) 'Argonauts' has at least ten Block 3F, F-35Cs. It must also have the requisite spares, supply chain and a functional Autonomic Logistic Information System.

The Argonauts achieved its safe-for-flight operations certificate on December 12, 2018

after it completed aircraft carrier qualifications aboard USS Carl Vinson (CVN 70). The certificate confirms that the squadron is manned with personnel qualified to implement maintenance and safety programmes in support of fleet operations. All transitioning Navy squadrons are required to complete this certification prior to independently conducting flight operations on a new aircraft.

As well as the above, the ship from which the jet will operate must possess the proper infrastructure, qualifications and certifications.

Finally, the F-35 Joint Program Office, industry, and Naval Aviation must demonstrate that all procedures, processes and policies are in place to sustain operations. F-35C production lags significantly behind that of the F-35A and F-35B, and only three dozen or so have been delivered to the Navy. IOC was supposed to be conditional upon the completion

of IOT&E (Initial Operational Test and Evaluation), which is being undertaken at Edwards Air Force Base, California by the US Navy's Air Test and Evaluation Squadron 9 (VX-9) 'Vampires', but, for some reason, that requirement has been dispensed with. Commencement of the IOT&E effort slipped by nine months, so a conservative estimate would project the completion date as being January or February 2020 as opposed to the earlier estimate of April 2019. However, the duration of IOT&E has been cut to seven months meaning it is scheduled to end in September 2019. The actual date is anybody's guess because of continuing problems with certifying software for the jet. the Autonomic Logistics Information System, for instance, is so problematical that the Air Force is developing alternative software.

The delay in completing IOT&E is not as significant as it may appear. VFA-147's first cruise with its new mount is not scheduled until 2021.

New Hampshire retires its Stratotankers



New Hampshire Air National's 157th Air Refueling Wing divested itself of all its KC-135R Stratotanker aircraft by March 24, 2019. The veteran tankers' replacements, 12 brand-new KC-46A Pegasus are expected to arrive at the unit's Pease Air National Guard Base home starting in the late summer. The flight crew of KC-135R Stratotanker 58-0104 pose for a group photo prior to flying the aircraft to Scott Air Force Base, home of the Illinois Air National Guard's 126th Air Refuelling Wing on January 30, 2019. TSgt Aaron Vezeau/New Hampshire Air National Guard

New Nepalese Skytrucks

The US Department of Defense has contracted Poland's biggest aircraft manufacturer Polskie Zakłady Lotnicze Mielec, to supply two new M28 Block 05 Skytruck aircraft to Nepal.

The \$18.9 million firm-fixed-price foreign military sales contract, announced on March 1, also provides for associated initial maintenance training, technical publications, and ferry flights from Mielec, Poland, to Kathmandu, home of the Nepal Army Air Wing's 11th Brigade.

Freedom Fighters to Predators

Talavera la Real Air Base in Badajoz will become the Ejército del Aire's operational base of the Predator B. The new unmanned air vehicles will operate alongside veteran F-5M advanced trainers. **Roberto Yáñez** and **Alex Rodríguez** provide the latest news

CURRENTLY, TALAVERA la Real Air Base is home to the Ejército del Aire's Escuela de Caza y Ataque (Fighter and Attack School), where future Spanish fighter pilots graduate from a hard and demanding five-year course of study.

Training begins at the Academia General del Aire (AGA) in San Javier, Murcia where students undergo their first four years of study and training as pilots. Each year, around a dozen students are selected to complete their fifth year of training at Talavera for the fighter and attack phase.

Escuela de Caza y Ataque

Established in 1953, the jet school at Talavera initially provided training with Lockheed T-33As, then North American F-86F Sabres, until November 1970 when they were replaced by the CASA/Northrop SF-5B Freedom Fighter. In 1987 the school was redesignated Ala 23 de

Instrucción de Caza y Ataque (23rd Fighter and Attack Training Wing) still operating the same SF-5Bs. The aircraft remain in operation today having undergone various structural and avionics modifications in order to facilitate pilot transition to the EF-18 Hornet and Eurofighter.

Between 1992 and 2003 Ala 23 also operated a handful of single-seat SF-5A and SRF-5A Freedom Fighters, which were at the end of their operational lives; all of the F-5As had come from Morón and Gando Air Bases.

Since its beginning in 1953, the school has run over 100 flight courses and graduated over 2,000 pilots. Originally equipped with 34 two-seat SF-5Bs, around 20 remain in service, all modernized and upgraded to F-5M standard.

Most recently, the wings were replaced by the Maestranza Aérea de Albacete (MAESAL), which added an additional 2,000 flight hours to each aircraft; the first F-5Ms are now

expected to be withdrawn in 2020.

Several options are currently being studied as part of a plan to replace the aircraft used for basic and advanced training. In recent months, there has been talk of a possible agreement between Spain and South Korea for the exchange of between four and six A400M transports drawn from Spain's 27-aircraft order, in return for 20 Korean Aerospace Industries T-50 Golden Eagle advanced trainers and 30 KT-1 Woongbi basic trainers.

This supposed agreement is a solution to a problem to be faced by the Ejército del Aire when Ala 23's F-5Ms and the AGA's CASA C101 Aviojet aircraft are withdrawn from service; C101s are also in the last phase of their useful life. The Aviojets are expected to be withdrawn starting in 2021.

According to Korean sources, Spain and South Korea hoped to start negotiations at the end of February to finalize the exchange.

Predator arrival

While the future of the Ejército del Aire's training fleet is still being decided, what is a reality is the imminent arrival at Talavera of the first Class III Remotely Piloted Air System to operate in Spain; the MQ-9 Predator B manufactured by General Atomics Aeronautical Systems Inc.

Among various Ejército del Aire programmes underway is development of the Escuela de UAS (Unmanned Aerial Vehicle School) established at Salamanca Air Base, and to increase intelligence, surveillance and reconnaissance capabilities through acquisition of high capability drones.

In November 2015, Spain ordered four Block 5 MQ-9 Predator B drones valued at €158 million. This is a major acquisition for the Spanish armed forces, since they will gain the ability to conduct surveillance, strategic tracking and intelligence as part of worldwide

During each course there are typically three periods of flying during which students receive the necessary instruction before being assigned to Ejército del Aire fighter squadrons.

All photos by Roberto Yáñez unless noted

Official patch of the Spanish Predator B programme office.

Ejército del Aire



During a period lasting nearly 50 years, Ejército del Aire F-5Ms have been used to train more than 2,000 fighter pilots. Despite its age, periodic upgrades have given optimum performance to train pilots.



Talavera la Real's flight line, where aspiring Ejército del Aire fighter pilots undertake their fifth and final year of studies before joining a frontline fighter squadron.



Argentine Air Force pilots have been temporarily assigned to Ala 23 at Talavera for several years.



An artist's rendering of an
Ejército del Aire Predator.
Ejército del Aire



military operations, and to support the Ministry of the Interior by conducting border patrol and maritime surveillance missions.

The contract between the Spanish Ministry of Defence and GA-ASI is a US Foreign Military Sale between the two nations. All four aircraft will receive mission payloads (one for each aircraft and a spare) comprising the DAS-1A Multispectral Targeting System Model B; 16 Embedded GPS/INS navigators with Selective Availability

Anti-Spoofing Module, three for each air vehicle and four as initial spares; four APY-8A Block 20A Lynx II multimode radars, plus an option for a fifth; one mobile maintenance test station to facilitate first level maintenance of the air vehicle, along with an option for a second.

Two Block 30 ground control stations with beyond-line-of-sight SATCOM data link and line-of-sight communications are also on order, with an option for a third.

An initial two-year logistical support contract has also been signed with the manufacturer covering the supply of spare parts, support equipment, any necessary training, provision of up-to-date technical manuals, and engineering services associated with the program.

Programme delays have already occurred, the first two Predator B air vehicles and one ground control station are expected to arrive at Talavera by November; all remaining

deliveries are scheduled to take place during 2020.

The Ejército del Aire is already preparing infrastructure at Talavera in preparation for the MQ-9s. Until the permanent buildings are built, two large temporary hangars have been set up to house the aircraft, spares, control systems and data links. New antennas are being erected to operate the drones. The airfield at Lanzarote in the Canary Island has been selected as a forward deployment base for the



ABOVE LEFT: Although its primary mission has always been training, the F-5M maintains a capability to employ weapons, some of which are loaded on aircraft AE9-07.

ABOVE RIGHT: Within the next five years the Ejército del Aire will retire its fleets of F-5M Freedom Fighters and C101 Aviojet trainers.



Predator B; construction will also take place at Lanzarote to support MQ-9 operations.

233 Escuadrón

The MQ-9 will enter Ejército del Aire service Ala 23's 233 Escuadrón and operate under the NR.05 designation; N denoting unmanned, R for its primary role of reconnaissance, and 5 because it's the fifth RPAS to enter Ejército del Aire service.

Unlike other countries, Spanish Reapers will not employ air-to-

ground munitions or carry external fuel tanks but will be configured for future modification to carry munitions if required.

Despite the armed option, Ejército del Aire MQ-9s will remain ISR platforms, while the unmanned strike role is likely to be assigned to a future long-range European RPAS being developed by Spain in conjunction with Germany, France and Italy.

Mechanics and operators assigned to the new unit, are receiving their initial training in the United States. A

large contingent of the maintenance personnel trained with New York Air National Guard's 174th Attack Wing based at Hancock Field Air National Guard Base at Syracuse. The first two crews (each comprising a pilot and a sensor operator) were trained at Holloman Air Force Base, New Mexico and Nellis Air Force Base, Nevada, between September 2017 and August 2018.

The Ejército del Aire's plan comprises eight crews; training the additional personnel will take place

in Spain by the crews already trained in the US, supported by US military personnel at Talavera. The first crews will be pilots from the EF-18 Hornet and Eurofighter forces, and air controllers; at least one transport and one helicopter pilot have already qualified on the MQ-9.

Arrival of the last two MQ-9s will coincide with the 50th anniversary of the first F-5 Freedom Fighters for Ala 23 at Talavera; two significant Ejército del Aire milestones that highlight the unit's past and future operations.



ABOVE RIGHT: Some of the Ejército del Aire personnel posted to the United States to undergo training with the MQ-9 Predator B pose in front of a US Air Force example. Many of the maintainers trained with the New York Air National Guard's 174th Attack Wing based at Syracuse-Hancock Field. *Ejército del Aire*

Djibouti receives upgraded Dauphins



The four Dauphins have been overhauled in Romania prior to being transported to Djibouti aboard an Antonov An124M-100 transport aircraft.

The Force Aérienne du Djibouti (Djibouti Air Force) has taken delivery of four AS365N Dauphin helicopters after a two-year upgrade by Airbus Helicopters in Romania.

The helicopters arrived partially disassembled in Djibouti on January 16, 2019, aboard an Antonov An-124-100M.

The helicopters were originally delivered in 2016 from Saudi Arabia, which is believed to have financed the aircraft. They were then sent to Romania for a €5 million overhaul and upgrade.

One Dauphin was converted into a VIP transport (for four passengers), two were converted for passenger transport and

one was left in its original medical configuration. (All four helicopters were previously used by the Royal Saudi Armed Forces Medical Services.)

Former Saudi serials of the four AS365s are HZ-MS15 (msn 6153), HZ-MS18 (msn 6156), HZ-MS20 (msn 6158) and HZ-MS21 (msn 6161). *Guy Martin*

Subaru delivers utility helicopter

Subaru has delivered the first prototype of its New Utility Helicopter to the Japanese Ministry of Defense, the company announced on February 28, 2019.

Subaru has developed the New Utility Helicopter from the civil Bell 412 EPX, in partnership with the US manufacturer. Development of the new variant began in September 2015 and flight testing began in December 2018. The first prototype will now undergo a further series of flight tests by the Japan Ministry of Defence before being cleared for production.

A Subaru spokesperson said: "[The] Subaru Bell 412 EPX obtained approval of the design change of Japanese Type Certification from [the] Japan Civil Aviation Bureau on January 18, 2019. Subaru will expand [the] defence business, as well as the production and sales of the Subaru Bell 412 EPX, which is for the commercial market."

Nigel Pittaway

Additional Japanese H225

The Japan Coast Guard (JCG) has received an additional H225 Super Puma helicopter, bringing its total to 13 – two AS332s and 11 H225s – Airbus Helicopters announced on March 6, 2019.

The Super Pumas are used by the JCG for security enforcement, coastal surveillance and humanitarian air and disaster relief operations throughout Japan and its territorial waters.

Guillaume Leprince, Airbus Helicopter Japan's Managing Director, said: "The fact that JCG's latest H225 participated in a series of rescue missions immediately upon delivery and rescued 23 people speaks volumes for our aircraft's mission-ready performance and availability... This follow-on order also reaffirms the confidence the JCG has in our helicopters." *Nigel Pittaway*

Selected: P&W Canada's PW206B3



Airbus Helicopters made the engine selection announcement at the Heli-Expo 2019 exhibition in Atlanta, Georgia, on March 6, 2019. *Airbus Helicopters*

Airbus Helicopters announced on March 6, 2019, that it has selected the Pratt & Whitney Canada PW206B3 engine to power the H135 variant, its proposal for the US Department of the Navy requirement.

The H135 is being offered for the Navy's training helicopter

programme, known as the Advanced Helicopter Training System, and, if successful, the company intends to manufacture the helicopters at its North American production facility in Columbus, Mississippi.

Chris Emerson, President of Airbus Helicopters Inc and Head

of the North America Region, said: "Pratt & Whitney engines power a large proportion of the H135 fleet flying in North America and we feel this choice reinforces the H135 as the best-value solution for Navy's initial entry rotary-wing pilot training requirement." *Nigel Pittaway*

CH-53 reset delivered



CH-53E Super Stallion BuNo 161282/YJ02 prepares for take off from Marine Corps Air Station Futenma, Okinawa, Japan, on March 7, 2019. Lance Corporal Madeline Jones/US Marine Corps

Marine Heavy Helicopter Squadron 465 (HMH-465) has taken delivery of the first Sikorsky CH-53E Sea Stallion, BuNo 161282/YJ02, to complete the H-53 Reset programme in the Western Pacific.

The announcement, made on March 7, 2019, marked the return of the helicopter following a combined planned maintenance interval (PMI) and H-53 Reset

managed by the Fleet Readiness Center Western Pacific.

Maintenance on the helicopter was performed by Korean Air Lines in Busan, South Korea. A PMI is required every 900–1,600 flight hours or ten years, whichever occurs first. According to the US Marine Corps, the PMI accomplishes preventative, corrective and investigative maintenance functions

designed to improve aircraft material condition and facilitate availability.

Lieutenant Colonel Christopher Roy, Commanding Officer of HMH-465 said: "The Reset programme's goal is to provide long-term health to the CH-53E. Reset aircraft have proven to be more reliable, with higher mission-capable rates, than non-Reset aircraft." Nigel Pittaway

Dutch helicopters exercise in the UK

In late February 2019, eight helicopters from the Netherlands Defensie Helicopter Commando (Defence Helicopter Command) deployed to Carlisle Airport in Cumbria for two weeks of extensive electronic warfare training at nearby RAF Spadeadam.

Last held in 2016, Exercise Tac Blaze UK 2019 saw 250 troops, 80 vehicles and eight helicopters use Carlisle Airport as a forward operating base for the flight training phase, between February 25 and March 8, 2019.

The eight aircraft comprised three CH-47D Chinooks (298 Squadron), three AH-64D Apaches (301 Squadron) and two AS532U2 Cougars (300 Squadron), all from Gilze-Rijen Air Base.

Covering 9,600 acres, RAF Spadeadam is the largest Royal Air Force station by land area. It is also the only electronic warfare tactics facility in Europe where aircrews can practise manoeuvres and tactics against a variety of threats they might face in warfare. Ian Harding

MD 969

MD Helicopters Inc (MDHI) has launched an evolution of its MD 900/MD 902 helicopter, named MD 969, at the Heli-Expo exhibition in Atlanta, Georgia, on March 5, 2019.

The MD 969 features the Genesys Aerosystems Advanced IDU-680 glass cockpit, similar to that already fitted to MDHI's MD 530G attack helicopters, and a proprietary-designed plank that allows for up to six stations of forward-firing weapons, while allowing unimpeded access to the helicopter's cabin.

Brochure performance figures include a maximum gross take-off weight of 6,770lb (3,070kg), a useful load of 3,395lb (1,540kg), a range of 366 nautical miles (679km) and a cruise speed of 160kts (296km/h).

Lynn Tilton, CEO of MDHI, said: "The MD 969 will deliver a new level of multimission capabilities for military operators. As we continue to develop the helicopter for our military customers and prepare for development of future attack and reconnaissance aircraft, we have a roadmap that significantly expands the performance envelope of the MD 969, creating a foundation for other future twin-engine development efforts."

Nigel Pittaway

H135s for Brazilian Navy



The new H135s will be used for a range of roles in Força Aeronaval da Marinha do Brasil service, potentially including support for the country's Antarctic programme. Airbus Helicopters

Airbus Helicopters announced on January 21, 2019, that the Força Aeronaval da Marinha do Brasil (Brazilian Navy) has ordered three H135s to replace some of its existing UH-13 (Aerospatiale AS355F2) helicopters.

The new helicopters will be operated by the 1st General Purpose Helicopter Squadron (HU-1) based at São Pedro da Aldeia and two will be configured for aeromedical transportation. Other equipment will include

an emergency flotation system, cargo hook, external winch and a weather radar system and the fleet will be capable of performing a range of missions, including special operations support, troop transport and SAR. Nigel Pittaway

British Airways orders 777X



Long-time Boeing 777 operator British Airways has signed an agreement for up to 42 777-9s. *Boeing*

British Airways (BA) has chosen the Boeing 777X to re-equip part of its long-haul fleet, signing an agreement with the manufacturer for up to 42 777-9s, comprising 18 orders and 24 options. The jets are due to be delivered from 2022 to 2025.

The 777-9 purchase continues the large fleet renewal that has been underway at BA for much of this decade and has seen the airline introduce the 787, 777-300ER and A380 and begin phasing out its 747-400s. The 777-9s will be used to serve the

carrier's long-haul trunk routes, replacing older 777s and the 747-400s the airline uses to operate the bulk of this network. BA will also use 18 Airbus A350-1000s, the first of which will be delivered this summer, to operate these routes. The A380 is used for routes with the largest passenger flows and the 787s for network development and routes with thinner passenger demand.

BA is planning to phase out its last 747 in 2023 and Willie Walsh, the Chief Executive Officer of BA's parent company IAG,

described the 777-9 as a "perfect replacement", saying: "This aircraft will provide further cost efficiencies and environmental benefits with fuel cost per seat improvements of 30% compared to the 747. It also provides an enhanced passenger experience."

Ordering the 777-9 continues BA's long relationship with the Triple Seven. BA was a launch customer for the original 777 back in 1990, the initial European operator in 1995 and is one of the largest 777 operators worldwide, with a fleet of 58.

Taking 777-9s means the airline will gain from commonality in spares and maintenance with the current 777 and shared type ratings for crews. With BA's sizeable 777 fleet, there is clearly further potential for Boeing to sell more 777-9s to IAG.

BA's selection of the 777-9 meant Boeing had sold 344 777Xs by early March, comprising 291 777-9s and 53 777-8s, after Etihad Airways, one of the 777X launch customers in 2013, cut down its 777-9 order from 25 to just six jets. *Mark Broadbent*

Rolls-Royce backs away from NMA

Rolls-Royce has withdrawn from the competition to supply an engine for Boeing's proposed New Mid-market Airplane (NMA), saying it is "unable to commit" to the proposed development timetable for the potential new midsize airliner.

The engine manufacturer previously said the UltraFan engine it is currently developing would be available from the mid-2020s, which would have fitted Boeing's service-entry aspirations if it developed the NMA.

However, Rolls-Royce now says that timeline would not satisfy its internal requirements for technical maturity of the UltraFan. The company said: "Meeting Boeing's timetable would have required accelerating our demonstrator programme and withdrawing from the process will enable us to have a high confidence in engine maturity towards the end of the next decade."

Chris Cholerton, Rolls-Royce's President Civil Aerospace, commented: "This is the right decision for Rolls-Royce and the best approach for Boeing. We had

begun [the UltraFan's] development before the Boeing opportunity emerged and it must undergo a rigorous testing regime before we offer it to customers, which we do not believe can be achieved within the NMA timeframe."

Rolls-Royce said even though it won't pursue the potential NMA it will continue to mature its engine technologies. The company recently tested the composite elements of the Advanced Low-Pressure System, including fan blades, a fan case and annulus fillers, for the UltraFan engine architecture. Rolls-Royce describes UltraFan as the foundation of its future large civil aero engine programmes, offering a 25% fuel efficiency improvement over first-generation Trent engines.

Rolls-Royce's withdrawal from the NMA engine contest leaves CFM International and Pratt & Whitney as the two contenders to power an aircraft that it is proposed will seat 220-270 passengers and have a range of 5,000 nautical miles (9,260km). Boeing will decide this year whether to offer the NMA to



Rolls-Royce has withdrawn from the contest to power Boeing's potential New Mid-market Airplane, but development work on its UltraFan engine continues.

Rolls-Royce

market before making a firm launch decision in 2020. If it did launch the NMA it aims to bring the jet, widely dubbed the 797 in the industry, to market in 2025.

Delta Air Lines' Chief Executive Officer Ed Bastian recently repeated his airline's interest in the NMA, telling investors during the JP

Morgan Aviation, Transportation and Industrials Conference the airline has, "almost 200 aircraft between the 757s and 767s that we need to replace over the next decade. We are in discussions at a very preliminary phase with Boeing on it. Hopefully they'll decide to go [ahead]." *Mark Broadbent*

Long-haul flagship



The A350-1000 will be Airbus' highest-capacity airliner once A380 production ends. A Doumenjou/Airbus

With the A350 now Airbus' flagship long-haul airliner after the company axed the A380, there is likely to be renewed attention on the potential future evolution of the European twin-jet as it becomes the company's highest-capacity, longest-range product.

Airbus last year ruled out stretching the A350-1000, the largest current A350 variant, in the short term. The company had assessed a new variant dubbed the A350-2000 with more capacity (reportedly above 400 seats) and an increased maximum take-off weight, but while the manufacturer

said such an aircraft is technically feasible it shelved the concept for the time being.

One reason, company executives said, was that a new generation of more fuel-efficient turbofan engines would not become available until the mid-2020s. Another important factor cited in putting an A350-2000 on ice was weak demand for the largest twin-aisle widebody airliners, a trend reflected by the A380's demise.

With the A380 axed (no super jumbos will be produced after 2021), the decks in Airbus' product line-up are now clearer. An A350

with 400-plus seats would clearly have encroached on the super jumbo's territory, but with the A380 now gone there is an opportunity for Airbus by blending A380-style high capacity and the A350's twin-engine economics to satisfy requirements at the top of the commercial aircraft market for the largest airliners. Such an aircraft would clearly offer competition to the 777-9, the next-generation Triple Seven due to fly this year and enter service in 2020.

Outgoing Airbus Chief Executive Officer Tom Enders recently said Emirates' decision to order 40

A350-900s, which happened four years after the carrier cancelled a previous order for the type, "is a strong testament that this is a platform seen as highly competitive with a lot of potential".

Qatar Airways recently said it is interested in an A350 with a higher maximum take-off weight, with the Gulf carrier's Chief Executive Officer Akbar Al-Baker saying such an aircraft would complement the Boeing 777-9s the carrier has ordered and which will replace the carrier's A380s from 2024. Airbus Commercial Aircraft President Guillaume Faury recently acknowledged: "It's always very important to listen to customers. I'm convinced the A350 has a lot of potential and I'm happy to see that Akbar [Al-Baker] is sharing this point of view."

Other airlines might be interested in a stretched A350, or at least a package of improvements to the existing A350-1000 to provide extra performance. Qantas, which has challenged Airbus and Boeing to modify their respective A350 and 777 to make possible direct ultra-long-haul flights such as London-Sydney with a full payload, has said it wants to complete a request for proposals this year. The A350's part in the market for big twin-jets seems like one to watch.

Mark Broadbent

Cargo conversion

The first Aeronautical Engineers Inc (AEI) Boeing 737-800SF freighter conversion has been delivered by its customer, the lessor GE Capital Aviation Services (GECAS), after the conversion received supplementary type certification (STC) from the US Federal Aviation Administration.

The 737-800SF conversion, ET-AVX (c/n 29121, ex-N598CB), was completed by AEI in December 2018, but there was a delay in its certification due to the partial shutdown of the United States government holding up the FAA certification process. The aircraft was delivered by GECAS to Ethiopian Airlines Cargo in February.

The AEI-converted 737-800SF offers a main deck payload of up to 52,700lb (23,904kg) and 2,000 nautical miles (3,750km) range. The conversion incorporates 11 full-height (88 x 125in/2.2 x 3.1m) container positions, plus an additional position for an AEP/

AEH. It incorporates a reinforced floor, a large 86 x 137in (2.1 x 3.4m) main cargo door with a single vent door system and a flexible Ancra Cargo Loading System, a rigid 9g barrier, up to five supernumerary seats, a galley and full lavatory. AEI says its conversion provides operators with an ability to open new markets carrying express cargo on short-haul routes while offering newer technology, lower fuel consumption and better reliability than standard-body freighters.

The 737-800SF is one of three passenger-to-freighter (P2F) conversion options now available for the 737-800, with the others being Boeing's in-house 737-800BCF (Boeing Converted Freighter) and IAI Bedek's 737-800BDSF. The 737-800BCF entered service in 2018, with GECAS again the first customer, delivering the initial example to West Atlantic. GECAS has to date announced plans to have at least



The Boeing 737-800SF conversion offers a main deck payload of up to 52,700lb (23,904kg). Aeronautical Engineers Inc

50 737-800 passenger aircraft converted to freighters.

AEI forecasts 750 737-800s will undergo freighter conversion over the next 40-plus years and it says it can capture around half of that market. The company has already secured 111 firm orders and commitments for the 737-

800SF. The Miami-based company now holds more than 120 STCs for conversions of various single-aisle aircraft from regional jets up to narrowbodies. The organisation said it sees continuing demand for its 737-400SF conversion for 737-400s as well as 737-800 conversions. Mark Broadbent

'Serbia Creates' A330



Air Serbia's sole Airbus A330-202 YU-ARA 'Nikola Tesla' (msn 885) has been repainted with a special livery featuring numerous words emblazoned across the tail to promote a Serbian Government campaign called 'Serbia Creates'. The aircraft is pictured departing Belgrade for New York JFK in March. *Igor Salinger*

Valencia FC logojet



Air Nostrum Bombardier CRJ1000 EC-MXA (c/n 19060), operated for Iberia Express, now wears stickers marking the centenary of the Spanish football club Valencia. The livery depicts all the trophies won by the club during its history, the legend 'Un sentiment etern' on the fuselage meaning, 'An eternal feeling'.

José Ramón Valero

One hundred Hertz



This Eurowings Airbus A320-214 D-ABDU (msn 3516), photographed on approach to Palma, has recently been repainted in a colourful livery to mark the centenary of the car hire firm Hertz. *Javier Rodríguez*

INNUMBERS



63

AIRBUS SINGLE-AISLES

Airbus has confirmed plans to ramp-up production of its A320 Family to 63 aircraft per month. The company said last year it was studying the possibility of hiking output of its single-aisle range and it says it is aiming to achieve this rate in 2021. The company said it is "on track" to achieve an interim rate increase to 60 jets per month, up from the current 57/month rate, in the middle of this year. Mark Broadbent

AIRBUS

Customer	Aircraft	Number	Date
Air Vanuatu	A220-100	2	February 25
	A220-300	2	February 25
Emirates	A330-900	40 HOA	February 14
	A350-900	30 HOA	February 14

BOEING

Customer	Aircraft	Number	Date
Bamboo Airways	787-9	10	February 27
IAG (for British Airways)	777-9	18 plus 24 options, purchase commitment	February 28
Unidentified	737	9	Announced February 12
Unidentified	787	18	Announced February 12
VietJet	737 MAX 8	20	February 28
	737 MAX 10	80	February 28

BOMBARDIER

Customer	Aircraft	Number	Date
Chorus Aviation (for Jazz)	CRJ900	5	February 6

SUKHOI

Customer	Aircraft	Number	Date
Thai Kom Airlines	SSJ-100	6	February 28

1

WIZZ AIR A321NEO

The Hungarian low-cost carrier Wizz Air received the first of what will be 174 Airbus A321neo deliveries. The airline is set to become the leading European operator of the largest A320neo Family variant, the carrier already operating 36 A321-200s and due to receive five more. Deliveries of the Wizz Air A321neos will take until 2022 to complete. Mark Broadbent

140

EMIRATES FLIGHTS TO UK

Emirates will from this summer operate a second daily flight to London Stansted, bringing the total weekly flights to the UK from Dubai served by the Gulf carrier to 140. There are six services a day from Heathrow, three from London Gatwick and Manchester, two from Birmingham, Glasgow and Stansted, and a daily service from Newcastle and Edinburgh. Mark Broadbent

1

BOEING 737 MAX 8 FOR COMAIR

Comair, operator of British Airways and Kulula flights in South Africa, has taken delivery of its first 737 MAX 8 from Boeing. The aircraft, ZS-ZCA (c/n 60432), arrived in South Africa from Seattle on February 28 via refuelling stops in the Dominican Republic, Cape Verde and Ghana, having departed two days earlier. The 189-seat aircraft will be flown in British Airways livery and maintained by Lufthansa Technik. When Comair ordered eight 737 MAX 8s it became the first airline in southern Africa to acquire the model, which will replace its 737-400s. (Mauritania Airlines and Ethiopian Airlines have also received 737 MAX 8s.) Deliveries will conclude in 2022, contributing to the airline's efforts to get modern aircraft to reduce operating costs. (The 737 MAX 8 uses 14% less fuel than its predecessor). Comair's two brands fly to 11 destinations in southern Africa and the Indian Ocean using 18 737-800s, seven 737-400s and three A320-200s wet leased from Global Aviation Operations. Another four leased 737-800s will be acquired to replace the 737-400s. Guy Martin

8

AIR BALTIC 737 CLASSICS TO RETIRE

Air Baltic is to phase out its eight remaining Boeing 737 Classics earlier than planned. The Latvian carrier plans to end operations with its six Boeing 737-300s and two 737-500s in autumn 2019, enabling it to focus on a single fleet type in the form of the Airbus A220-300. Air Baltic now has 14 A220-300s in service, the airline having 50 on firm order along with 30 options. A total of 60 A220 Family aircraft had been delivered by the start of March, consisting of 14 A220-100s and 46 A220-300s. Mark Broadbent

INBRIEF

Airbus order cancellations

Airbus recently suffered a heavy few weeks of order cancellations, with the company's latest orders and deliveries data showing orders for more than 90 aircraft were removed from its backlog in February. Etihad Airways cancelled 40 A350-900s and two A350-1000s, while Airbus has withdrawn 22 A380s (20 ordered by the lessor Amedeo and two attributed to Air Accord), 25 A320neos and five A220-100s. Airbus only secured four orders in the first two months of the year. Mark Broadbent

Air France-KLM wants widebodies

The Air France-KLM Group is seeking new medium-haul widebody aircraft and will launch a tender this year, the group said in its full-year financial results for 2018. It confirmed plans to phase out Air France's remaining Airbus A340s in 2020 and KLM's last Boeing 747-400s in 2021, and that Air France's A380 fleet will be reduced from ten jets to seven by 2021 as leases on three super jumbos expire. Meanwhile, the European Commission has approved Air France-KLM's bid to buy 31% of Virgin Atlantic Airways. The Franco-Dutch group is the second-largest stakeholder in the UK carrier after Delta (49%) and the Virgin Group (20%). Mark Broadbent

JetBlue across the Atlantic?

JetBlue could be about to launch routes to the UK from its New York and Boston hubs. A move by the US airline into the transatlantic air travel arena has long been rumoured by airline industry-watchers, especially after the carrier ordered the long-range Airbus A321LR variant that can serve the market. The airline's Chief Executive Officer, Robert Hayes, has previously said the carrier could take advantage of what he called "a good opportunity" for transatlantic air travel. Mark Broadbent

Flybe sale

The acquisition of the UK regional carrier Flybe by Connect Airways, a company owned jointly by Virgin Atlantic, Stobart Air and a US-based hedge fund called Cyrus Capital, was confirmed in March. Flybe is now no longer on the London Stock Exchange as a public listed company. The new owners said Flybe's operations will continue and that the Exeter-based carrier would continue to operate as an independent company, although the carrier is expected to be rebranded at some point. Mark Broadbent

Flybmi collapse

Flybmi went into administration in February 2019. The UK regional airline, legally registered as British Midland Regional Limited and formerly branded bmi Regional, operated scheduled services from UK regional airports across Europe, with its head office at East Midlands Airport. Flybmi was a former subsidiary of BMI, which was acquired in 2012 by IAG from Lufthansa. While BMI was integrated into BA, the regional operation was sold to Sector Aviation Holdings and operated as an independent regional airline from October 2012. In August 2015 Flybmi became part of a new regional airline group, Airline Investments Limited, along with Loganair. Flybmi's demise means the last trace of the British Midland/BMI name has now disappeared. Mark Broadbent

Retrojets

Wes Bushell and **Mark Broadbent** report on British Airways bringing back the livery of its forerunner companies

ON FEBRUARY 18, 2019, British Airways Boeing 747-436 G-BYGC (c/n 25923) left the International Aerospace Coatings (IAC) hangar at Dublin Airport in Ireland wearing the historic livery of the British Overseas Airways Corporation (BOAC).

Arriving at London's Heathrow Airport following its short flight using the call sign BA100, the retro-painted 747 taxied to the British Airways maintenance base for a welcoming ceremony where it was met by past and present British Airways and BOAC staff in representative uniforms.

The famous livery adorned BOAC aircraft between 1963 and 1974 and was worn on the airline's first Boeing 747-136s in the early 1970s. BOAC's speedbird logo has of course continued to be used by British Airways and the word 'speedbird' is the airline's radio call sign.

Centenary celebration

The BOAC livery has been resurrected by British Airways as part of celebrations to mark its 100th anniversary.

G-BYGC is one four aircraft with retro schemes inspired by the airline's history. BOAC and British European Airways (BEA) merged in 1974 to create today's British Airways.

The second jet to receive a retro livery, which entered the IAC paint shop in Shannon on February 23, is Airbus A319-131 G-EUPJ (msn 1232), which now wears the famous BEA scheme with the red square.

The livery on G-EUPJ is not quite an exact replica of the BEA colours. One of the characteristics of the original BEA livery was red-painted upper surfaces on the wings. On the A319 these upper surfaces will be grey instead, to meet current wing paint reflectivity requirements.



Airbus A319-131 G-EUPJ (msn 1232) now wears the famous BEA scheme with the red square.

Landor 747

On March 1, British Airways announced the third retrojet design (or "heritage liveries" as BA calls them), which is Boeing 747-436 G-BNLY (c/n 27090) painted in the Landor design.

The aircraft went to the IAC paint bay at Dublin to be repainted in the scheme BA's aircraft wore between 1984 to the introduction of the short-lived World Tails in 1997. The design features the BA coat of arms with the airline's motto 'To Fly, To Serve' on the tail fin and a stylised Union Flag.

The 747 has also been renamed 'City of Swansea', the name the aircraft had when it originally sported the Landor livery on its delivery to BA back in 1993.

The Landor livery also features the airlines' centenary logo, which is displayed on all the aircraft which will wear the old liveries.

The aircraft returned to Heathrow and entered service in mid-March flying to long-haul destinations served by the Boeing 747. As with the BOAC livery on G-BYGC, the scheme will remain on the 747 until it retires in 2023.

Boeing 747-436 G-BYGC (c/n 25923), pictured at a gloomy Heathrow, is the first of four British Airways aircraft to be repainted as retrojets as part of the carrier's centenary celebrations.

All photos Wes Bushell unless stated





The third retrojet was Boeing 747-436 G-CIVB (c/n 25811) which wears the Landon livery used from 1984 to 1997. *British Airways*



The retrojets have been painted by International Aerospace Coatings.

Negus 747

After a lot of speculation, BA confirmed the fourth and final retrojet design is the first version of the Negus livery worn by the airline's aircraft from the BOAC/BEA merger in 1974 to 1980 (a modified version of the livery with larger 'British' titles was used from 1980 until the introduction of the Landon design in 1984). When it initially appeared, the Negus livery was the first time an aircraft had carried the title British Airways title since 1939, when the original British Airways Limited merged with Imperial Airways to form BOAC.

Boeing 747-436 G-CIVB (c/n 25811), like the BOAC and Landon jets, was repainted by IAC in Dublin. Alex Cruz, British Airways' Chairman and CEO, said the Negus design is, "particularly significant for us because it's the first design worn by the British Airways that we all know today, with the distinctive lower case 'a' and the Union Flag on the tailfin".

The Negus 747 was due back at Heathrow late in March. All new aircraft joining the BA fleet, including the A350-1000 due to arrive in summer 2019, will continue to receive the airline's current Chatham Dockyard design.



XQ-58A Valkyrie test flight

A new long-range, high-subsonic unmanned demonstrator conducted its first flight at the Yuma Proving Grounds in Arizona on March 5. The XQ-58A Valkyrie has been developed by Kratos Unmanned Aerial Systems and the US Air Force Research Laboratory (AFRL).

The aircraft is part of the AFRL's Low Cost Attributable Aircraft Technology (LCAAT) portfolio and is a demonstrator for an unmanned combat air vehicle that can operate alongside manned platforms in the Loyal Wingman role. The AFRL's XQ-58A programme manager Doug Szczublewski said the X-58A, "is the first example of a class of UAV that is defined by low procurement and operating costs while providing game-changing combat capability".

The US Air Force says the LCAAT's objective is, "to break



The XQ-58A Valkyrie demonstrator during its March 5, 2019, inaugural flight at the Yuma Proving Grounds. US Air Force

the escalating cost trajectory of tactically relevant aircraft" by developing better design tools and using commercial manufacturing processes to reduce development time and cost.

The AFRL said the aircraft completed 76 minutes of flight and "behaved as expected". The system will carry out five test flights in two phases with objectives that include evaluating system functionality,

aerodynamic performance and launch and recovery systems.

Kratos was awarded a contract in July 2016 to develop a LCAAT demonstrator. When the contract was announced, Kratos said the demonstrator would provide a configurable design capable of conducting various missions including defensive counter air manoeuvres, offensive counter air manoeuvres, suppression of enemy

air defences and the destruction of enemy air defences.

Kratos said the stated AFRL goals for the LCAAT programme are to produce a system capable of a Mach 0.9 dash, 1,500 nautical miles (2,778km) combat radius with a 500lb (226kg) payload and an internal weapons capability, sized to carry and deliver at least two GBU-39 small diameter bombs.

Mark Broadbent

On call for oil spills

Unmanned systems are now part of the response capabilities available in the event of an oil spill, after Oil Spill Response Ltd (OSRL) signed agreements with third-party UAV providers Bristow Aerial Solutions, Sky-Futures and Vertical Horizon Media.

The UK-based OSRL is the world's largest international spill response organisation. The new agreements make UAVs available as reconnaissance/surveillance tools for OSRL members, with the intention to provide better response capabilities. An OSRL spokesperson told AIR International: "UAVs can be utilised to identify the thicker patches of oil offshore and to support offshore containment and recovery operations and vessel dispersant application."

OSRL offers an aerial dispersant capability with two Boeing 727s operated by T2 Aviation at Doncaster Sheffield Airport, the former RAF Finningley. The spokesperson emphasised UAVs will

not be used to direct aerial spraying, but said they could assist in monitoring dispersant effectiveness.

OSRL said each of the three companies that will provide the UAV services was selected based on their relevant in-country experience, technical capabilities or geographical reach, "and will ensure OSRL members have the most appropriate and effective solution to the specific challenge in hand". The agreements mean a range of unmanned systems equipped with HD visual and infrared sensors can be called upon, including the Intel Falcon 8, DJI's Matrice M200, Matrice 210 RTK and Inspire 2 and Flyability Elios.

The unmanned service will have pre-agreed rates, defined mobilisation procedures and a standardised approach to managing response activities. It is mobilised through the OSRL duty manager and is subject to flight permissions and the meeting of regulatory requirements. Mark Broadbent



In the event of an oil spill, UAVs are now part of the available response capabilities. Oil Spill Response Ltd

Next-gen unmanned K-MAX



Kaman is developing a new version of the unmanned K-MAX. Kaman Aerospace

Kaman Aerospace is developing a new generation of its unmanned K-MAX, with the company saying it expects to offer kits for new production and existing aircraft in 2020.

Kaman also said it is, "exploring opportunities to support the US Marine Corps in developing co-use versions of autonomous aerial technologies that will have both commercial and military applications".

Kaman said the next generation unmanned K-MAX will offer, "unmatched readiness and efficiency no matter the requirement". Roles such as night-time aerial fire-

fighting, resupplying troops in austere environments or delivering critical supplies in support of humanitarian missions are all envisaged for the system.

The unmanned K-MAX supported the US Marine Corps in Afghanistan on combat resupply and logistical support missions from 2011, moving over 4.5 million pounds (more than 2 million kg) of cargo to remote outposts. Certified in 1994, the single-engine K-MAX is a rugged low-maintenance aircraft with a distinctive counter-rotating rotor system optimised for external load operations. Mark Broadbent

Camcopter S-100 in Nigeria

Schiebel's Camcopter S-100 Unmanned Air System recently demonstrated its capabilities to a large European oil and gas corporation during trials in Rivers State, Nigeria. The energy industry has shown interest in unmanned systems to monitor and control

infrastructure and the trials were, Schiebel said, "designed to further investigate the implementation and potential advantages" of the technology. The S-100 completed both day and night flights monitoring pipelines and inspecting wellheads and facilities.

Tritons on track



A full-scale mock-up of the Triton, complete with Royal Australian Air Force markings and the serial number A57-001, was on display at Avalon 2019. Nigel Pittaway

Speaking at the Australian International Airshow at Avalon in February, the Royal Australian Air Force's Director of Intelligence, Surveillance, Reconnaissance and Electronic Warfare, Group Captain Jason Lind, provided details of Australia's Northrop Grumman MQ-4C Triton acquisition programme.

Gp Capt Lind said that the first of six Tritons the Air Force acquires will be delivered on schedule in mid-2023.

Australia has an overall requirement for six Tritons and Minister for Defence Christopher Pyne announced an order for the first aircraft in June 2018. Other aircraft will be ordered as the programme matures and there is also an option for a seventh MQ-4 Triton as an attrition replacement

at a later date.

The Triton is being acquired under the AUD 4 billion Project Air 7000 Phase 1B, which calls for an unmanned, persistent maritime intelligence, surveillance and reconnaissance platform to supplement the Air Force's Boeing P-8A Poseidon aircraft. Together, the two platforms are replacing the Air Force's Lockheed AP-3C Orions, which were recently withdrawn from service in the maritime ISR and anti-submarine warfare roles.

Gp Capt Lind said the initial order, which included the first aircraft and ground control stations, was valued at AUD 1.4 billion.

Australia is acquiring the US Navy's multi-intelligence version of the Triton and all aircraft are

expected to be in service by the end of 2025.

Gp Capt Lind said that Australia has also signed up to a cooperative development programme with the US Navy, in order to influence the further development of the Triton's capabilities. A similar arrangement exists between the Royal Australian Air Force and US Navy for the P-8A and this has reportedly been very successful to date.

He said: "We have learned a lot of things and derived a lot of goodness out of the Poseidon cooperative programme and we'll be working closely with the US Navy to further develop Triton, and how we can leverage off some of their methodologies as well."

The first Australian crews will travel to the United States in 2020, to begin their training with a US

Navy MQ-4 squadron.

In Royal Australian Air Force service, the Tritons will be based at Edinburgh in South Australia, but they will also operate from RAAF Base Tindal in the Northern Territory and other deployed locations around Australia. The Triton will be part of the Air Force's Surveillance and Control Group, but a decision on which squadron will operate the aircraft is yet to be made.

Gp Capt Lind said: "I think Triton brings something incredibly different to the Royal Australian Air Force and the wider Australian Defence Force and the cooperative development programme will deliver something beyond a foreign military sales acquisition. We're a partner with the US Navy and we've started early."

BLOS capability

The US Air Force has demonstrated a beyond line of sight (BLOS) control capability for its Northrop Grumman EQ-4 Global Hawk.

In February 2019, the Air Force announced it had been operating the EQ-4 from Al Dhafra in the United Arab Emirates using BLOS satcom technology. Previously, control of the aircraft while airborne has required coordination with a number of other bases.

An Air Force spokesman from the 380th Expeditionary Aircraft

Maintenance Squadron said: "The BLOS [capability] plays a major role, because it allows us to fly the jet farther than any launch and recovery element could ever before, utilising satcom as its main link, rather than a line of sight link. With a 24/7 mission requiring an aircraft to be always in the sky, EQ-4 pilots and maintainers can plan, launch and execute missions locally, without relying on other bases."

The BLOS capability was set-up at Al Dhafra in September 2018.

A-100 test programme

Russian news agency TASS announced on February 9, 2019, that the Beriev A-100 Airborne Warning and Control System (AWACS) aircraft under development for the Russian Air Force (VVS) has begun a new phase of flight testing, described as a programme of "prior test flights".

The news agency quoted a Russian Ministry of Defence spokesperson as saying: "The latest A-100 multifunctional AWACS aircraft was embarked on a programme of prior test flights and made a maiden flight."

The A-100 is a modification of the Ilyushin Il-76MD-90A (Il-476) transport aircraft. The aircraft is

intended to replace the Russian Air Force's fleet of Beriev A-50 and A-50U 'Mainstay' platforms.

The first aircraft flew from the Taganrog Aviation Scientific and Technical Complex in November 2017 and, according to Russian sources, deliveries are expected to begin in 2020.

The Russian Ministry of Defence said: "The A-100 has been developed due to the emergence of new target classes and the creation of new-generation multi-role fighter aviation. Its capabilities considerably exceed both domestic and foreign analogues, including the [Boeing] E-3 [Sentry] AWACS of the US Air Force."

Aero India 2019

Piotr Butowski uncovers the current status of indigenous Indian aviation programmes and international acquisitions during a visit to Aero India in late February

JUDGING BY numbers, the Aero India exhibition is shrinking year by year. This year 414 companies from all over the world (including 247 from India) took part; 135 less than 2017, and 209 less than 2015. The number of participating aircraft was also smaller; fortunately, there were some noteworthy novelties among them.

The largest foreign nation participating was France, represented by 45 companies, all looking for industrial partners with which to discharge offsets connected with India's purchase of Rafale fighters; a story that has rumbled on ever since. Back on January 31, 2012, the Dassault Rafale was declared the winner of India's Medium Multi-Role Combat Aircraft (MMRCA) tender for 126 fighter aircraft. This tender was later cancelled and instead on September 23, 2016, the Indian government contracted 36 (plus an option for 18 more) off-the-

shelf Rafale aircraft under an inter-governmental agreement with France. The contract for Rafale generated contentious disputes in India; now even more heated, just weeks before the country's general elections planned for April and May 2019. The first Rafales will enter Indian Air Force service in September; three Armée de l'Air Rafales were at Aero India 2019; two B-models in the flying display and one C-model on static display.

Also notable was the American presence, which included 37 exhibitors and a US Air Force B-52H bomber in the opening air parade. Over the last decade, the United States has become India's biggest military equipment provider delivering C-17 Globemaster III and C-130J Super Hercules transports, P-8I Poseidon maritime patrol aircraft, and CH-47F(I) Chinook and AH-64E Apache helicopters. Now

American defence companies are hoping to win even larger contracts involving 114 fighters for the Indian Air Force, 57 carrier borne fighters and 22 unmanned air vehicles for the Indian Navy. Russia's presence was far more modest with 23 companies involved, but no aircraft.

India's MiG-21 Bison is an indigenous upgrade featuring a Russian slotted-array Kopyo radar to enable use of beyond-visual range air-to-air missiles, and a mix of French, Indian, Israeli and Russian systems.

All images by Piotr Butowski

Opening parade

The most spectacular part of each Aero India exhibition is the air parade staged on the opening day; it is the only time, when Indian Air Force and Indian Naval aircraft from other bases fly over Yelahanka. Flight displays on subsequent show days only involve the aircraft on the exhibition flight line.

The most interesting guests debuting at this year's show were the veteran MiG-21 Bison fighter, a P-8I Poseidon and a B-52H Stratofortress. More than 1,200 MiG-21s have been operated by the Indian Air Force since 1963; Aero India 2019 was one of the last chances to see an Indian MiG-21 perform a public display. India's MiG-21 fighters will be retired in the coming years because of their

age; flying at Yelahanka was MiG-21 Bison, serial number CU2820, piloted by Group Captain Dasgupta.

The Boeing P-8I is a variant of the P-8A Poseidon customised for India; beginning in May 2013, the first of eight aircraft started to replace the obsolete Tu-142ME in Indian naval aviation service. India ordered another four P-8Is in July 2016 to be delivered by 2020.

During a rehearsal on the eve of the opening day, two Hawk Mk132 aircraft assigned to the Indian Air Force Surya Kiran aerobatic team collided in mid-air; one of the pilots, Wing Commander Sahil Gandhi, was killed. During the opening day's air parade, Wing Commander Sahil Gandhi was honoured by a 'missing man' formation over the crash site comprising a Su-30MKI, Jaguar and Tejas.



A Su-30MKI, Jaguar and Tejas aircraft flying a missing man formation in memory of Wing Commander Sahil Gandhi.

Is 42 an axiom?

Many years ago the Indian Air Force declared that to provide defence of the nation, 42 combat aircraft squadrons were needed. However, instead of approaching that number, the Indian Air Force is receding more and more from that goal. As the service life of old MiG-21 and MiG-27 fighters is nearing their end, and delivery of new fighters is slow, the force capability gap gets greater.

Currently, the Indian Air Force has 31 combat squadrons, in contrast with 33 in 2017 and 35 in 2015; a squadron's allotted strength is 16 to 18 aircraft. The need for 42 fighter squadrons is

increasingly and often questioned in India, as befits the world's largest democracy – in both directions. Some maintain this level was specified a long time ago, when tactical combat aircraft were single role, either fighter or strike, and today all new aircraft are multi-role and therefore a smaller number is sufficient to perform assigned tasks. Opponents claim that India needs far more than 42 fighter squadrons due to the growing capability of Chinese and Pakistani air arms.

Multi-role fighter aircraft

New fighter aircraft are still needed by the Indian Air Force. Cancelled, the MMRCA programme

found its extension in a new fighter procurement programme codenamed the Multi-Role Fighter Aircraft (MRFA) with the requirement for 114 made-in-India fighter aircraft; the request for information was issued by the Indian Air Force in April 2018.

The MRFA programme is to be implemented under the new Strategic Partner (SP) procurement model, one that envisages manufacture of military hardware by an Indian Production Agency (IPA) in collaboration with a foreign Original Equipment Manufacturer (OEM) that provides advanced technologies and sets up production facilities in India.

For MRFA, 18 aircraft would be procured in a flyaway condition from the OEM, while the balance is to be built by an IPA in India.

The same companies that bid for the MMRCA are now bidding for the MRFA, with minor updates. On the first day of Aero India 2019, Lockheed Martin announced that from now on its offer was known as the F-21, stressing that the new designator is not a Block 70 F-16. In reality, the F-21 is an F-16, but one that's different inside and out. Why Lockheed Martin has dubbed its Indian F-16 as the F-21 remains unclear.

Under the US Department of Defense's unified tri-service



A model of the Lockheed Martin F-21. If selected as winner of the MRFA competition, all 114 aircraft would be manufactured in India by Lockheed Martin and Tata Advanced Systems.



LCA Tejas KH2012 fitted with an indigenous Uttam active electronically-scanned array radar under a transparent nose cone and two Brahmos-NG air-to-surface missiles loaded under the wing.



India's Electronics and Radar Development Establishment is offering the Uttam active electronically scanned array radar for future versions of the Tejas Light Combat Aircraft.

designation system, in operation since September 1962, the F-21 designation was given to the Israeli Kfir C.1 fighter, 25 of which were leased by the US Department of the Navy and used as adversary aircraft by the US Navy's Fighter Squadron 43 (VF-43) based at Naval Air Station Oceana, Virginia (12 aircraft, 1985-1988) and Marine Fighter Training Squadron 401 (VMFT-401) based at Marine Corps Air Station Yuma, Arizona (13 aircraft, 1987-1989). Under the DoD designation system, a type designator is generally not used again.

The reasons behind the F-21 label are politically driven; an aircraft operated by Pakistan (the F-16) is probably best not to be offered to India.

Whatever designation used by Lockheed Martin, if selected for the MRFA, the aircraft will be manufactured by the company in collaboration with India's Tata Advanced Systems at a new facility in India.

One new candidate has joined the previous six; Sukhoi's Su-35, offered by Russia. This is an unusual candidate since the Su-35 is a

heavy-class of fighter, the Indian Air Force already has eleven squadrons of Su-30MKIs, and its requirement is for a medium class fighter, in size terms, one that's between the Su-30MKI and the Tejas.

The new MRFA programme found little reflection at this year's exhibition; of the seven companies bidding for the contract, only Boeing and Dassault had aircraft at Bengaluru; Boeing with the F/A-18 Super Hornet and Dassault with Rafale, though a US Air Force F-16C was present. Others limited themselves to a full-size mock-up (Saab JAS 39 Gripen E) or small models (Eurofighter Typhoon, Lockheed Martin F-16, RSK MiG MiG-35, and Sukhoi Su-35). No wonder: companies have concluded that investing money at such an early stage of the procurement is not justified, after all, the aircraft types are already well-known, because all but the Su-35 have previously appeared at Bengaluru.

A second programme that may be related to the Air Force's MRFA is the Indian Navy's requirement for 57 fighters for its future aircraft carriers in a programme dubbed the Multi-Role Carrier Borne Fighter (MRCBF), for which an RFI was issued in January 2017. Two of the strongest MRCBF candidates - the F/A-18 Super Hornet and the Dassault Rafale M - are also bidding for the MRFA.

More Flankers and Fulcrums
By December 2018 the Hindustan

Aeronautics Ltd (HAL) facility in Nasik had produced 203 Su-30MKI fighters of 222 ordered (the first 50 aircraft were delivered directly from Russia); thus the entire current contract will be fulfilled in the next fiscal year, ending in March 2020.

After fulfilling the order, HAL is seeking to fill its available production capacity, and the Indian government is considering buying another batch of Su-30MKIs.

According to Anatoly Punchuk, deputy head of Russia's Federal Service for Military Technical Cooperation, in January 2019 Russia received an official request for 18 aircraft from India. Accordingly, Russian manufacturer Irkut is to provide HAL Nasik with the raw materials and sub-systems needed to build the additional fighters.

After Su-30MKI production has ceased, HAL will be able to use its empty production capacity with major overhauls, and then upgrades of Indian Air Force Su-30MKIs. The scope of the upgrade, colloquially called the Super 30, is still unspecified, but there is no doubt it will be undertaken and HAL will be the main contractor.

Quite unexpectedly, a couple of weeks before Aero India a Russian offer appeared to sell 21 MiG-29 fighters, made from abandoned half-airframes, commenced and unfinished at MiG's Lkhovitsy facility near Moscow.

Reportedly the unit price is only \$25 million and supposedly the

Tejas LA-5006 is the sixth IOC-standard series production aircraft in service with the 45 Squadron 'Flying Daggers' stationed at Sulur.





Ukrainian company Antonov displayed the An-132D light transport aircraft in a bid to attract customers from southeast Asia.

aircraft would be delivered in a simple configuration. From India's perspective, upgrading these aircraft to the most advanced MiG-29UPG standard makes sense, but would almost double the unit price. The Indian Air Force currently has three squadrons equipped with MiG-29s which are undergoing a mid-life upgrade to MiG-29UPG standard.

Getting straight

On December 31, 2018 the Centre for Military Airworthiness & Certification (CEMILAC) cleared production documentation for the Tejas Light Combat Aircraft (LCA) Mk1 in its final operational clearance (but actually limited FOC) standard. On February 20, the first day of the exhibition, the FOC certificate was ceremonially



Differences to the aerodynamic configurations of the LCA Navy Mk1 and Mk2 (at the rear) include leading-edge vortex controllers on the wing of the Mk1 and small control surfaces on the tail of the Mk2.



India's Advanced Medium Combat Aircraft project developed by the Aeronautical Development Agency may go through a major transformation when the winning bid for the MRFA is invited to join the programme in the future.

presented to the Air Force Chief, Air Chief Marshal Birender Singh Dhanoa. Since Aero India 2017, the Tejas passed several milestones; successfully launching a Derby air-to-air beyond visual range missile in radar-guided mode on May 12, 2017, and completed aerial refuelling trials in September 2018.

All 16 aircraft ordered in the first batch (manufactured to the initial operational clearance standard approved in December 2013) will be complete by March 2019. That means in FY2018-2019 the HAL facility in Bengaluru will produce eight Tejas aircraft, using the full capacity of the production line's current capability.

The FOC certificate presented to Air Chief Marshal Birender Singh Dhanoa enables production launch of the second batch of aircraft to FOC standard; the first of them, SP-21 is due to fly in October 2019. HAL reckons that all 16 Tejas Mk1 FOC aircraft will be complete by March 2020.

To date, the Indian Air Force has placed two orders for the Tejas LCA Mk1: the first placed in 2006 covers 20 IOC standard aircraft, the second placed in 2010 covers 20 FOC standard aircraft. Each batch includes four two-seat

trainer variants, which is a problem because the two-seat version has yet to receive its clearance and the reason why each of the two orders actually covers just 16 jets.

Aircraft built in the first IOC production batch are being assigned to the 45 Squadron 'Flying Daggers', formed in June 2016 at Bengaluru, and from July 2018 redeployed to Air Force Station Sulur; 18 Squadron will form and use the FOC standard aircraft.

Chasing export orders, the Tejas was expected to be demonstrated at the LIMA 2019 show in Langkawi, Malaysia as part of the bid for the Tentera Udara Diraja Malaysia's 36-aircraft fighter programme; this the second overseas demonstration after the 2016 Bahrain International Air Show. Other potential customers are Sri Lanka and Vietnam.

Mark 1A

In November 2016, India's Defence Acquisition Council accepted the purchase of 83 LCA fighters in the improved Mk1A standard (including ten two-seat trainers); in December 2017 the Indian Ministry of Defence issued the relevant acceptance of necessity declaration, but the order is still awaiting technical clearance from the Indian Air Force. During



Model debut of the LCA Navy Mk2, which features two small tail plane surfaces fitted to the lower part of the engine nacelle, the position that on earlier models displayed air-to-air housed leading-edge vortex controllers.

Aero India 2019, HAL Chairman and Managing Director, R Madhavan expressed hope that a firm order for Mk1A aircraft would be signed in one or two months, and the first aircraft would be complete in 2022. Fulfilment of the entire 83-aircraft order would be complete within 3-4 years for which HAL would launch another Tejas assembly line at Bengaluru, allowing the production rate to increase from eight to 16 aircraft per year. Further in to the future the production rate

could attain 24 aircraft per year. India's government assigned INR 13.81 billion for the programme as early as March 2017.

Uttam AESA radar

In accordance with Indian Air Force requirements, the Tejas Mk1A modification, retaining the present airframe and engine, will be fitted with an active electronically scanned antennae radar, new beyond-visual range air-to-air missiles, a jamming system with

Tejas LCA and MWF characteristics

	LCA	MWF
Length	13.2m (43ft 4in)	14.6m (47ft 11in)
Wing span	8.2m (26ft 11in)	8.5m (27ft 11in)
Height	4.4m (14ft 5in)	4.9m (16ft 1in)
Max take-off weight	13,500kg (29,762lb)	17,500kg (38,581lb)
Top speed	Mach 1.6	Mach 1.8
Ceiling	49,200ft (15,000m)	50,000ft (15,240m)
G-limit	+9/-3.5	+9/-3.2
Engine type	GE F404-IN20	GE F414-INS6
Engine thrust	84.3kN (18,960lb)	98.1kN (22,046lb)



Upgraded Saras prototype PT1N re-started flight testing on January 24, 2018. The planned Mk2 production version is designed to transport 19 passengers over 430 nautical miles.

The Saras performed a flight demonstration every day.



an integral warning sensor and a pod-mounted jammer, and aerial refuelling capability. Maintenance is to be facilitated thanks to easier access to the aircraft systems and interchangeable modules. Some of the improvements, including the maintenance aspects and aerial refuelling capability are already complete.

Ambiguity associated with the modification programme concerns the AESA radar and missile. Current Tejas fighters are equipped with Israeli systems; a mechanically scanned, slotted-array Elta EL/M-2032 radar and I-Derby extended range beyond visual range missiles (as well as the smaller Israeli Python 5 and Russian R-73E air-to-air missiles).

In December 2018, HAL signed a contract with Israeli company Elta for EL/M-2052 AESA radars, and a self-protection pod for the Tejas Mk1A.

Selection of the EL/M-2052 was based on a lower price; this type of radar will also be fitted to upgraded Indian Air Force Jaguars, and will be produced in India by an Indian-Israeli joint venture. So what about problems? MBDA's Meteor missile is an important stick for the Indian Air Force to acquire, but MBDA is denied the ability to integrate the Meteor missile on an aircraft fitted with a non-European radar.

However, India's Defence Research and Development Organization (DRDO) showed another option at Aero India 2019: aircraft KH2012 (LSP-2, the second limited series production aircraft) fitted with an indigenous Uttam AESA radar. MBDA is cleared to integrate the Meteor missile with the Uttam, a system made by the Electronics and Radar Development Establishment (LRDE), a part of DRDO.

Aircraft KH2012 was also loaded with two Brahmos-NG air-to-surface missiles. Weighing 1,400kg (3,086lb), this next generation missile, previously referred to as the Brahmos-M or Mini, is a down-sized version of the original Brahmos-A suitable for a small fighter such as the Tejas. It's big sister, the Brahmos-A has a range of 320 nautical miles (600km), a terminal speed of Mach 2.5 and weighs 2,550kg (5,622lb); the first air launch of a Brahmos-A missile was fired by a Su-30MKI on November 22, 2017.

Right now, Brahmos-NG is a mock-up, but judging by Indian Air Force demand, and a moderate level of complexity in manufacturing, the Brahmos-NG missile is likely to be built. Nota bene, this year's variant of the missile differs from the one previously displayed in the shape of its wing: originally the Brahmos-NG

had a two-piece wing but the latest mock-up features an X-wing similar to the type used on the Brahmos-A.

Medium weight fighter

India's Aeronautical Development Agency (ADA), the government agency responsible for designing the Tejas, showed models of two new versions, one for the Air Force and one for the Navy; both differ from the previously shown Mk2 models.

The variant for the Air Force, previously known as the LCA Mk2, has been renamed the Medium Weight Fighter (MWF) to reflect its 30% weight increase in comparison with earlier versions of the LCA Mk1.

The MWF will be powered by the higher-thrust GE Aviation F414-INS6 engine and will be capable of carrying a much heavier weapons payload. A new element of the MWF configuration are coupled canard



A HAL Dhruv adapted for ship-based operations with folding rotor blades and a folding tail boom is a contender for the India's Naval Utility Helicopter.

fore planes, absent in the earlier LCA Mk2 design. Air Chief Marshal Dhanoa said earlier that the Indian Air Force is willing to have 12 MWF-equipped squadrons: a fleet of over 200 fighters.

The future naval carrier-based variant, the LCA Navy Mk2, also has a new configuration. As early as December 2009, a decision was made that the initial LCA Navy Mk1 version would only be used for testing and pilot training and not for carrier-borne operations. To date, two LCA Navy Mk1 prototypes have completed over 150 test flights, including 18 ski-jump take-offs, but no arrested landings because tail hook integration and landing gear strength tests have yet to be completed.

Currently the Indian Navy is running the MRCBF programme to meet its requirement for 57 carrier-borne fighters which will complement its fleet of 45 Russian MiG-29Ks. Nevertheless, the Navy continues to fund development work on the LCA Navy Mk2 aircraft, whose design is to be revised to optimize structure and weight, and improve aerodynamics. A model of the new LCA Navy Mk2 shown at Aero India 2019 featured two small tail plane surfaces fitted on the lower part of the engine nacelle but the leading-edge vortex controllers, previously mounted in the wing roots, have been removed.

Next-generation AMCA

India's ADA is also working yet another future fighter; the Advanced Medium Combat Aircraft (AMCA). Models of the AMCA shown at Aero India 2019 did not differ from those displayed at previous editions of the exhibition,

but more information about the programme appeared.

ADA Combat Aircraft Programme Director, Girish Deodhare claimed that four AMCA prototypes with provisional F414 engines would be completed and undergo testing "in about seven years" following which the up-scaled production version equipped with new, yet-to-be developed, higher-thrust engines would be developed.

However, India's next-generation fighter programme might be subjected to major transformations, because the Ministry of Defence is closely linking AMCA to the current 114-aircraft MRFA programme. This means the winner of the MRFA competition would be invited to participate in the AMCA programme further in the future. This might be the primary reason why the Russian Su-35 has entered the MRFA competition. The previous cooperative Russian-Indian next-generation fighter, the Perspective Multirole Fighter (PMF) or Fifth-Generation Fighter Aircraft (FGFA) project based on the Su-57 seems to have been terminated. When asked about a new-generation fighter, Air Force Chief Dhanoa did not even mention the FGFA preferring to only discuss the AMCA. At Bengaluru HAL Chairman and Managing Director R Madhavan described the Russian-Indian FGFA project as deferred.

Helicopter programmes

Centre stage of Hindustan Aeronautics Limited hall was occupied by a Dhruv helicopter adapted for ship-based operations with folding rotor blades and tail boom to enable stowage in ship hangars. With rotor blades and

tail boom folded, the helicopter's dimensions are reduced; the length from 15.85m (52ft) to 13.5m (44ft 3in); rotor diameter/width from 13.2m (43ft 4in) to 3.5m (11ft 6in); and the height from 5.06m (16ft 7in) to 4.2m (13ft 9in).

According to HAL, the helicopter can be armed with torpedoes, missiles, and depth charges, and fitted with additional navigation and communication equipment. HAL displayed the naval version at Aero India to promote Dhruv as a suitable contender for the Naval Utility Helicopter (NUH) programme, intended to replace the Navy's vintage Chetak helicopters. Production of two basic versions, the utility Dhruv Mk III and attack Mk IV Rudra, continues at the HAL Helicopter Complex in Bengaluru.

On February 12, India's Ministry of Defence issued an expression of interest document inviting Indian and foreign manufacturers to submit

bids for the production of 111 NUH helicopters (16 by an OEM and 95 by an IPA) under the Strategic Partner procurement model. The request for proposals is likely to be issued later this year.

Nota bene, two years ago the centre stage of the HAL stand was occupied by a full-scale mock-up of the 13-tonne Indian Multi-Role Helicopter (IMRH), which this year was relegated to a poster inside the exhibition hall; the IMRH is suspended awaiting further decisions.

Two prototypes of the single-engine Light Utility Helicopter (LUH) made their maiden flight since Aero India 2017; PT2 (registration ZJ-4630) on May 22, 2017 and PT3 (ZK-4640) on December 14, 2018. Aircraft PT1 (ZG-4620), the first prototype made its maiden flight on September 6, 2016. All three appeared at this year's exhibition.

One of the prototypes piloted by Unni Pillai and Anil Bhambhani climbed to 19,685ft (6,000m) at Bengaluru on December 7, 2018; a high service ceiling is one of the critical requirements for every Indian military helicopter.

Speaking at the exhibition, HAL Chairman and Managing Director, R Madhavan said by February 2019 the three LUH prototypes had logged 170 flight hours and that the flight test programme and operational clearance would be completed in September 2019.

HAL is self-funding LUH development, hoping for orders from the Indian Army and Air Force to replace their respective vintage Cheetak and Chetak helicopters. HAL claims it has "an in-principle order" for 187 LUHs; 126 for the Army and 61 for the Air Force.

LUH production is expected to be launched at a new facility at Tumakuru 75km (47 miles) from Bengaluru.

HAL's LUH has a rival: Russia's Kamov Ka-226T. This little cab will



ZJ-4630 is the second of three Light Utility Helicopter prototypes which collectively have accumulated 170 flight hours since flight testing began in September 2016.

Troops fast rope from a Dhruv Mk III utility helicopter during an assault operation supported by an armed Dhruv Mk IV Rudra.



be produced in India under an intergovernmental agreement; the Russians will deliver 60 helicopters and a further 140 will be produced in Bengaluru by an Indian-Russian joint venture. However, with a current Indian requirement for 485 light helicopters, there is a place for both the Ka-226 and the LUH.

Russia has already announced its intent to submit the Ka-226T as its contender for the NUH programme.

Progress in the Light Combat Helicopter (LCH) programme during the last couple of years has been minimal; other than the four prototypes no new helicopters have been built; three prototypes appeared at Aero India 2019.

Armament and fire control system tests are still in progress; the biggest achievement was a successful firing of an air-to-air missile against a moving aerial target on January 11, 2019.

India's Defence Acquisition Council approved procurement of an initial batch of 15 limited series production LCH helicopters some years ago, but there is no formal contract yet.

The Light Combat Helicopter is fitted with the same engine and rotor system as the Dhruv,

but features a new narrow fuselage with tandem crew seat configuration. LCH armament and its targeting system are adaptations of the systems equipping the Rudra; the armed version of the Dhruv ALH MkIV in production and in service with the Indian Army since February 2013.

Avro replacement

According to Air Chief Marshal Dhanoa, the Indian Air Force's fleet of Avro HS748 transport aircraft will be replaced by 56 Airbus C295 aircraft, and contract negotiations are nearing completion. Airbus will deliver 16 aircraft from its Seville, Spain production plant, with the remaining 40 produced in India at a production facility run by a joint venture between Airbus and Tata Aerospace and Defence. One C295, a Portuguese Air Force-operated C295MPA Persuader, was at the exhibition.

Another contender was present: Antonov's An-132D. Despite the unlikely reversal of the Indian Ministry of Defence's selection of the C295, the An-132 is a likely contender for the future replacement programme for An-32 aircraft. Antonov test pilots flew



incredible flight demonstration routines at the show, including manoeuvres untypical for a transport aircraft.

Saras reborn

Aero India is traditionally a military exhibition, and despite a 20-year forecast for 1,500 frames with a capacity exceeding 110 passengers, few civilian aircraft are displayed at the exhibition.

One such type, the Saras, India's first indigenous passenger aircraft

designed by the National Aerospace Laboratories (NAL) at Bengaluru, made a re-appearance at this year's exhibition.

The first prototype, PT1, flew as early as May 29, 2004, and the second (PT2) in April 2007. After PT2 crashed on March 6, 2009, the Saras programme was suspended; the aircraft proved to be too heavy, and required more powerful engines and improvements to its flight control systems.

NAL resumed the programme in 2016, and the re-designated PT1N prototype featuring new engine nacelles, improved flaps, an improved rudder, and a new cabin environment system made its first post-upgrade flight on January 24, 2018. PT1N was displayed at Aero India 2019.

NAL's planned production version dubbed the Mk2 will weigh much less, feature an improved flight control system, new avionics, have a 19 seat capacity (compared to 14 on the Mk1) and a pressurized cabin. The Mk2 will be powered by two PT6A engines providing capability to transport 19 passengers over a range of 430 nautical miles (800km) at an airspeed exceeding 270kts (500km/h).

Highlights in the heat

Nigel Pittaway provides a rundown of the latest biennial Australian International Airshow at Avalon

THE 2019 Australian International Airshow at Avalon, south of Melbourne, was held between February 26 and March 3, amid unusually hot and dusty conditions that saw temperatures regularly reach the high 30s (centigrade) and even low 40s on at least one of the public days.

According to the show organisers, 699 exhibitors from 30 nations and over 375 aircraft attended the event, which according to CEO Ian Honnery made Avalon the fourth largest airshow in the world and the largest in the southern hemisphere.

Avalon 2019 also notched up a number of firsts, including the Australian debut of the Gulfstream 600, the first full display by a Royal Australian Air Force Lockheed Martin F-35A Lightning II and the first daylight landing of a US Air Force Northrop

Grumman RQ-4B Global Hawk at an airshow.

Traditionally, the first three days of Avalon are given over to a trade event, which at Avalon 2019 began on the opening day with Chief of Air Force, Air Marshal 'Leo' Davies' fifth-generation showcase flying display. Titled 'Target Acquired', the event highlighted the Australian Defence Force's airpower capabilities with an integrated flying display that included a Royal Australian Air Force F-35A, Airbus KC-30A, Boeing C-17A Globemaster III, EA-18G Growler, E-7A Wedgetail, P-8A Poseidon and 'Classic' F/A-18A/B Hornets. The Royal Australian Navy showcased its recently acquired Sikorsky MH-60R Seahawk and the Australian Army Aviation Corps contributed two Airbus Helicopters Tiger Armed Reconnaissance Helicopters and a pair of Boeing CH-47F Chinooks.

Business aviation

While the Australian International Airshow has become a predominantly military event over the years, it is also well supported by the manufacturers of business aircraft, who see the Asia-Pacific region as a lucrative market.

This year, Gulfstream Aerospace was represented by examples of its new G600 and flagship G650ER, as well as its popular G550. Likewise, Embraer displayed its Phenom 300E and Legacy 500. Dassault contributed its flagship Falcon 8X as well as a locally registered Falcon 2000. Pilatus had two examples of its new PC-24 on display – including one aircraft now in service with Australia's Royal Flying Doctor Service, in air ambulance configuration.

Finally, there were single examples of the Cessna 525B Citation CJ3 and 680A Citation Latitude in the static line-up.

Future air mobility capability

With Australian airpower largely recapitalised over the past decade, the attention of the manufacturers of military aircraft focused on the Royal New Zealand Air Force's future air mobility capability (FAMC) requirements at Avalon 2019.

The FAMC project seeks to acquire one or two types of airlifter to replace the incumbent Lockheed C-130H Hercules and Boeing 757-2KC in both tactical and strategic airlift roles, beginning in the early part of the next decade. With the arguable exception of the Airbus Defence and Space C295, all likely contenders were present at Avalon 2019 in one form or another.

Airbus DS was keen to talk about the merits of its A400M, which was present at Avalon in the form of a Tentera Udara Diraja Malaysia (Royal



F-35A Lightning II A35-009 is one of two assigned to RAAF Base Williamtown with the tail markings of 3 Squadron.

The Royal Australian Air Force was able to burn up the sky with its spirited F-35A Lightning II demo display powered by the enormously powerful Pratt & Whitney F135 turbofan generating 40,000lb of thrust.



Malaysian Air Force) aircraft from 22 Skuadron at Subang, near Kuala Lumpur. During the show, Airbus leased the aircraft back to from the Air Force to operate a number of short demonstration flights, but the aircraft otherwise remained in the static aircraft park.

During the show, a senior Airbus DS official said that the A400M was now maturing in service with current operators and the company is now actively turning its attention to the export market. AIR International understands that negotiations with a number of customers are in the detail phases and at least one announcement may be forthcoming during the course of 2019.

A Kawasaki Heavy Industries (KHI) C-2 from the Japan Air Defense Force's 3rd Tactical Airlift Wing based at Miho participated in the daily flying display during Avalon 2019 and KHI was keen to extoll the aircraft's virtues in the exhibition halls.

A company representative told AIR International that KHI had been in discussion with the Royal New Zealand Air Force about the capabilities of the C-2 for "several years", but now that series





Textron Aviation's Citation 525B N46LW (c/n 525B0532) participated in Avalon 2019 boosting the business aviation component of the show.



Pilatus PC-24 VH-VWO (c/n 105) serving with Australia's Royal Flying Doctor Service attended Avalon 2019 in air ambulance configuration.

production is now underway (a seventh aircraft was delivered to the JASDF shortly before Avalon), it is formally offering the aircraft against the FAMC requirement.

The official said: "We have just started marketing the aircraft [and] we expect the C-2 to be in production for at least ten years."

The JASDF has a requirement for between 20 and 30 C-2s, to replace its ageing Kawasaki C-1 airlifters and the official said that KHI was also in talks with a number of countries other than New Zealand, but he declined to name either a specific country or region.

Leonardo is also offering the C-27J Spartan for at least the tactical component of the FAMC requirement and the company signed an agreement with Northrop Grumman Australia at Avalon 2019 to support the aircraft, should it be successful. Northrop Grumman Australia currently supports the Air Force's ten Spartans and under a memorandum of understanding signed on the second trade day of the show the two companies will jointly bid for the FAMC programme.

Maurizio De Mitri, Leonardo's Marketing and Sales Director, said: "With this partnership, we want to make Australia our hub for the C-27J in the region to provide New Zealand with true excellence. . . We are convinced that New Zealand would receive significant advantages by becoming the next Spartan customer."

A number of Royal Australian Air Force Lockheed Martin C-130J-30 Hercules were present at Avalon, participating both in static and flying displays, and Lockheed Martin's Director of International Business Development, Air Mobility and Maritime Missions, Rich Johnson, said the aircraft is also being offered for the FAMC programme.

Johnson also said that Lockheed Martin was in discussions with up to ten countries for C-130Js, including India, Indonesia, Japan, New Zealand, South Korea and Taiwan in the Asia-Pacific region alone.

In other New Zealand-related news at Avalon 2019, Airbus Australia Pacific announced it had won a contract extension for the support of the Royal New Zealand Air Force's Lockheed

C-130H and P-3K2 Orion fleets and will now also include the service's Kaman SH-2G(i) Super Seasprite helicopters.

Airbus Australia Pacific Managing Director Andrew Mathewson said: "The contract is split into two-year service blocks with the first block ending in June 2020. The scope includes aircraft maintenance, engine and propeller maintenance and component maintenance."

Herk additions

The Royal Australian Air Force has been quietly increasing the capability of its 12 C-130Js in a series of trials and upgrades under the auspices of Plan Jericho, the Chief of Air Force's vision of a fifth-generation future.

To underscore these new capabilities, one aircraft was featured in the static display at Avalon 2019, complete with underwing fuel tanks. The aircraft was positioned between an Army CH-47F Chinook helicopter and M1A1 Abrams Main Battle Tank, to represent an enhanced forward arming and refuelling point (FARP) capability.

While the FARP concept is far from new, a recent software block upgrade (Block Upgrade 6.1) has permitted maximum take-off weight to be increased to 174,000lb (79 tonnes), making the carriage of external tanks to either increase aircraft range or improve fuel offload in a FARP situation viable. The Royal Australian Air Force will permanently fit two aircraft with the external tanks, with the possibility of a third aircraft being modified at a later date.

Other enhancements being already trialled and now being rolled out through the Hercules fleet include a Link 16 Tactical Data Link and Northrop Grumman AAQ-24 Large Aircraft Infra-Red Countermeasures. The Royal Australian Air Force has also successfully trialled a Ka-band satcom system on one aircraft and is considering rolling this out through the fleet (subject to funding). It is also considering the adaption of Northrop Grumman AAQ-28 Litening targeting pods, to provide an intelligence, surveillance and reconnaissance (ISR) capability.

The Litening pods will become available in sufficient numbers as



Tentara Udara Diraja Malaysia A400 M54-04 operated by 22 Skuadron based at Subang, was leased back by Airbus Defence and flown to Avalon in a bid to woo the Royal New Zealand Air Force with the giant behemoth.



Avalon first-timer, the Gulfstream G600. Aircraft N600G (c/n 73005) is one of Gulfstream Aviation's demonstrator jets.

the Royal Australian Air Force draws down its 'Classic' Hornet fleet between now and the end of 2022, but funding is yet to be allocated.

Speaking prior to Avalon 2019, Air Commodore Bill Kourelakos, Commander of the Royal Australian Air Force Air Mobility Group, said: "If we were able to put a pod on the wing of the aircraft, we could obtain imagery of an objective area ourselves and pipe it through the satcom and be a provider of imagery back to Joint Headquarters . . . But it can't be at the expense of our primary mission, which is moving people and cargo. We are not in the business of turning the C-130J into a surveillance platform."

F-35 update

The Royal Australian Air Force used Avalon 2019 to provide an update on some of its major capability acquisition programmes, notably including the F-35A Lightning II, which is now beginning to replace the 'Classic' Hornet in the air combat role.

The first two F-35As were delivered to Australia in December last year and both were present at Avalon, taking part in the static and flying displays, including the first ever full handling display of the fifth-generation fighter in the southern hemisphere.

The two aircraft (actually the ninth and tenth Australian jets) are currently undergoing a two-year verification and validation (V&V) period of testing in the lead up to initial operational capability (IOC) for the type, scheduled to occur at the end of 2020. Six further aircraft will be delivered to Australia by the end of 2019, joining several others currently based in the United States to support international F-35 training.

On the opening day of Avalon 2019, Air Commodore Mike Kitcher, Commander Air Combat Group and Air Vice Marshal Leigh Gordon, Head Joint Strike Fighter Division, provided an overview of progress to date.

From an operational perspective, Air Cdre Kitcher said that the ten Royal Australian Air Force jets have flown a total of 2,600 hours and 1,750 sorties and there are currently 15 Air Force pilots trained on the aircraft: "There are still some challenges in the F-35 space, but they are relatively well documented [and] there are no surprises there. As the operational commander it's actually better than what I expected it to be by now . . . When you talk to the young aircrew, the men and women who fly the aircraft, there's no chance they want to go back to a Hornet or Super Hornet, they want to fly the F-35 and it's improving all the time."

Air Cdre Kitcher also revealed that the first Australian mission data files have recently been produced by the ACURL (Australia, Canada, United Kingdom Reprogramming Laboratory) in the United States, as part of sovereign F-35 capability.

Speaking about the two-year V&V programme, AVM Gordon said: "There's no doubt that this is a complex endeavour and the V&V programme is one of our key strategies to manage that complexity. We want to try everything twice – the first time, we want to try early enough that we can fix whatever goes wrong, to be able to successfully do it the second time . . . It's great to have the success we're having so far, but I wouldn't want to say that IOC is in the bag. There are things we have to work through, and respond to, but we are positive that we are doing the best we can to mitigate those risks."

Firebird for Australian Coastwatch programme

Northrop Grumman's Vice President and General Manager of Autonomous Systems Brian Chappel revealed that the company is offering its Firebird optionally manned ISR platform for Australia's replacement border surveillance requirement.

The Australian government, through the Department of



Dassault Aviation's flagship Falcon 8X F-GCDP (c/n 439) is a company demonstrator no doubt made light work of the long journey from Bordeaux-Mérignac to Avalon.

Home Affairs and its Border Force organisation, has recently released a request for information (RFI) to industry for a new maritime surveillance capability and Chappel Confirmed that Northrop Grumman has offered Firebird.

He said: "We haven't spoken to the Australian government yet, but it's an application and a mission set that we certainly believe has some applicability. We will be following that with Border Force very closely [and] we have responded to the RFI."

Firebird is a piston-engine medium-altitude long-endurance capability with an endurance of up to 30 hours. The Firebird is made from composite materials and developed by NG subsidiary

Scale Composites at Mojave, California. Two prototypes are now flying and a third will soon join the development programme, Chappel said. The launch customer is an undisclosed US government agency.

Chappel added: "We are marketing the airplane now because it has gotten to the stage where the initial production programme is assured and we wanted to make sure we were all good before we started talking to customers."

Chappel also said that other (as yet undisclosed) systems will be offered alongside Firebird when more details of Australia's maritime surveillance requirements are known.



US Air Force RQ-4 Global Hawk 08-035/GF wearing tail markings for the commander of Det 1, 69th Reconnaissance Group based at Anderson Air Force Base on the island of Guam.

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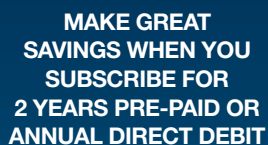
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Running late: US airpower in the FY2020 budget

By David C Isby

RUNNING LATE: the FY2020 budget request was supposed to be delivered to the Congress at the start of February. It appeared in mid-March, cutting down the time available to pass a budget and the Defense Authorization and Appropriation Bills, both of which are supposed to be signed into law by the time FY2020 starts on October 1, 2019. In 2017, Patrick Shanahan, the former Boeing executive who is now the acting Secretary of Defense, promised the FY2020 budget request would be this administration's masterpiece. It may also be its high-water mark.

The top line Department of Defense budget request is \$750 billion, a substantial increase from the \$719 billion in FY2019. The Budget Control Act caps – which led to sequestration – are back after a two-year hiatus. On March 13, Secretary of the Air Force Heather Wilson warned the Senate Appropriations Committee that sequestration would erase all the gains made over the last three years.

The Democrats, now a majority in the House of Representatives, have been moving to the left and are interested in cutting defence spending, anxious to be seen as opposing the president and also, for many, their party's own leadership.

This includes nuclear

modernization, with the Long Range Stand Off missile, intended to replace the AGM-86 Air Launched Cruise Missile, being identified as a potential target. Indeed, the budget submission contains much that is likely to lead to bitter disagreement both within and between the House and the Senate, still with a Republican majority.

This is the first new budget since the 2018 National Defense Strategy (which prioritised great power competition), the Nuclear Posture Review and the Missile Defense Review. The FY2020 budget is claimed to fund a new relationship with the industrial base and investment in key emerging technologies. Artificial intelligence

(\$900 million), unmanned technology and autonomy (\$3.7 billion), hypersonic technology (\$2.6 billion), directed energy (\$235 million), and many other areas all of which competed for the \$104 billion in research and development funding, a \$9 billion increase.

While the progress towards an operational test of hypersonic technology in the near-term future is attracting much of the attention. Speaking at a briefing in Washington DC on March 15, Assistant Secretary of the Air Force for Acquisition, Technology and Logistics, Dr Will Roper said he was desperate for the Air Force to place AI into operation because there is so little of it in the operational force.

AC-130J Ghost rider 16-5837 assigned to the 4th Special Operations Squadron at Hurlburt Field, Florida, on March 13, 2019. Aircraft 5837 is the first Block 30 AC-130J model received by Air Force Special Operations Command.

SSgt Victor Caputo/US Air Force



This Boeing image features a current variant of the F-15 Strike Eagle tooled-up with enough munitions and missiles to fight a small conflict on its own.



Air Force requests

The Air Force budget request did not fund any increase to its current 312 operational squadrons to its aspirational goal of 386, although Air Force Director of Strategic Planning, Major General David Krumm, said during a briefing in Washington DC on March 14 to expect some growth in the Future Years Defense Plan, which has yet to be released.

Nor does the Air Force FY2020 budget request contain any procurement money for the light attack aircraft programme that it had previously pushed the Congress to approve. However, \$35 million was requested for continued experimentation to enable off-the-shelf buys of six test aircraft; and a cool \$400 million procurement funding for light attack aircraft was postponed until FY2022-2024.

The Air Force has said for years it needs 72 new fighters a year. This year, it will not be getting them. The total number of F-35A Lightning IIs requested has been reduced to 48 (\$4.9 billion), while research and development spending for the F-35 - especially its Block 4 upgrade - has been increased by over 50% to \$800 million. The number of F-35As included is enough to equip two fighter squadrons.

Eight new-production Boeing F-15EX fighters (for \$1.1 billion) were included; 144 are planned, 80 by

FY2024. The F-15EX is increasingly controversial. On February 28, Secretary of the Air Force, Heather Wilson, told reporters that when she signed off the Air Force's FY2020 budget submission and sent it to the Department of Defense for approval, there were no F-15EXs in it. This statement appears to reflect widespread unhappiness over the F-15EX among senior Air Force leaders, anxious to increase fifth-generation combat aircraft. It will inevitably sharpen Congress' scrutiny of the programme.

The number of Boeing KC-46A Pegasus tankers, planned to be at a steady-state of 15 per year, was reduced to 12 to make up for three the Congress added last year. The number of Lockheed Martin special ops AC-130J Ghost Rider and MC-130J Commando II aircraft was reduced to eight from a planned 13. General Atomics MQ-9 Reaper unmanned air vehicles, planned at four, was increased to 12. Two types appear in the request as planned; 12 Sikorsky MH-60W combat rescue helicopters and one Gulfstream EC-37B Compass Call II.

In research and development funding, the big winners are the Northrop Grumman B-21 Raider bomber; the \$3.0 billion requested marks an increase of almost 50%, not counting funding in black world classified programmes. The Next Generation Air Dominance



An MH-47G Chinook assigned to the 160th Special Operations Aviation Regiment (Airborne) prepares to land on the aircraft carrier USS Carl Vinson (CVN 70) flight deck.

Mass Communication Specialist 3rd Class Sean Castellano/US Navy

programme – which could include a sixth-generation fighter and loyal wingman unmanned air vehicles – increased by over 50% to \$1 billion.

Army aviation requests

Procurement funding for Army aviation decreased to \$3.7 billion from \$4.3 billion, although an additional 15 UH-60M Black Hawks are added, increasing the buy to 73 (64 for the Army National Guard). The number of CH-47F Chinooks increased from seven to nine but the number of AH-64E Apaches (all rebuilt D models) held steady at 48. The new Future Attack Reconnaissance Helicopter programme requested \$427 billions of research and development funding. Special Operations Command (SOCOM) needs its MH-47G Chinook fleet upgraded, starting soon, and the Department of Defense added this urgent operational requirement to the budget. But the CH-47F Block II upgrade is not included in the request, its required funding is

instead the bill-payer for developing new high-performance rotorcraft.

DOT&E and the F-35

The Department of Defense's Directorate of Operational Test and Evaluation (DOT&E) submitted its annual report about its activities for FY2018 on time, in February. Unsurprisingly the F-35's entry is the largest in the report.

"There was no improving trend in fleet aircraft availability ... below the programme target value of 60% and well below the planned 80% needed for efficient conduct of IOT&E. The trend in fleet availability has been flat over the past three years; the programme's reliability improvement initiatives are still not translating into improved availability."

This trend will have to change to achieve the objective that former Secretary of Defense, James Mattis set in 2018; attain 80% mission capable rates within a year. The F-35's ability to do so, however, has been enhanced by a decision,

announced after Mattis had left the Pentagon, that the 80% target only applies to combat-coded aircraft. This means F-35s that are the least flyable will not be counted. These tend to be aircraft from early low rate initial production lots which are used for training or research and development.

The OT&E report was unimpressed by the F-35's Continuous Capability Development and Delivery (C2D2) initiative. Both the F-35 Joint Program Office and Lockheed Martin are relying on C2D2 to enable a more rapid development, testing, and fielding cycle for capabilities that are to be integrated as part of the F-35 Block 4 upgrades, and to address unresolved deficiencies from the F-35 System Development and Demonstration phase, which ended in 2018.

The DOT&E report considered the current C2D2 schedule as high risk due to the large amount of planned capabilities included in each six-month increment.

KC-46A: late again

After extensive delays, any sense of relief after the first delivery of Boeing KC-46A Pegasus tankers proved short-lived. An indefinite delay was placed on further KC-46 deliveries on March 1 after tools and other foreign objects were found in aircraft already delivered.

The Air Force is still examining the KC-46A aircraft involved for other defects. Boeing submitted a 13-step corrective plan. Deliveries were restarted on March 11, with a new KC-46A flying to the training schoolhouse at Altus Air Force Base, Oklahoma.

After high-level meetings with Boeing, Assistant Secretary of the Air Force for Acquisition, Technology and Logistics, Dr Will Roper was quoted as saying on March 13, "Boeing understands it's got a severe situation that's going to take top-level engagement from its company. They are committed to doing that."

US Navy requests 148 aircraft in FY2020 budget

By Rick Burgess

THE US Department of the Navy's FY2020 budget roll-out on March 12, 2019, has the department requesting procurement of 148 aircraft, an increase over the 134 funded in 2019.

The 148 aircraft requested for the Navy and Marine Corps will be funded by \$18.6 billion in 2020. The Department of Navy's overall aircraft inventory is scheduled to drop to 3,912 in 2020, down from 4,094 in 2019.

The fixed-wing aircraft requested include ten F-35B and ten F-35C Lightning IIs for the Marine Corps and ten F-35Cs for the Navy; 24 Block III F/A-18 Super Hornet strike fighters (more fighters than the Air Force gets this time around); four E-2D Advanced Hawkeye early warning aircraft; six P-8A Poseidon maritime surveillance aircraft; three KC-130J Super Hercules for the Marine Corps; and a one-time procurement of 22 Northrop F-5E Tiger IIs for Navy and Marine Corps adversary training aircraft.

Whereas Super Hornet procurement was slated to cease a few years ago, the aircraft is planned for procurement at least through 2024, for a total of 84 over the five years.

The six P-8A Poseidons in the budget are supposed to be the last for the US Navy, for a total of 117 production aircraft over the programme, but the Navy would

prefer to procure a total in excess of 130. In any case, the production line will be open for a few more years to meet the demand of foreign military sales.

The 22 F-5 adversary aircraft requested — 11 each for the Navy and Marine Corps — will be former Schweizer Luftwaffe aircraft and used to recapitalize older F-5s. The new F-5s will be operated by Fighter Composite Squadron 13 (VFC-13) 'Saints' based at Naval Air Station Fallon, Nevada and Marine Fighter Training squadron 401 (VMFT-401) 'Snipers' based at Marine Corps Air Station Yuma, Arizona.

Two of the three KC-130Js are slated for Marine Aerial Refueler Transport Squadron 252 (VMGR-252) based at Marine Corps Air Station Cherry Point, North Carolina.

Rotary-wing and tiltrotor aircraft requested in the budget include six CH-53K King Stallion heavy-lift helicopters and six VH-92A presidential transport helicopters for the Marine Corps; 38 new helicopters of a design to be selected in 2019 to replace TH-57 Sea Ranger training helicopters; and ten CMV-22B Osprey carrier-onboard-delivery aircraft for the Navy. Deliveries of more MV-22B Ospreys for the Marine Corps is gapped for 2020.

Large unmanned aircraft requested include two MQ-4C Tritons for the Navy and three MQ-9 Reaper medium-range unmanned air vehicles, the first of the type for

Upgraded HC-144B 2301 Ocean Sentry at Corpus Christi, Texas on February 20, 2019. Lt Jessica Wright/US Coast Guard



the Marine Corps. With three more Reapers planned, the Corps plans to operate six Reapers in preparation for a more advanced unmanned aerial vehicle.

The Navy's aircraft carrier fleet will be reduced to ten by 2025 as the USS Harry Truman (CVN 75) will be withdrawn from service rather than being overhauled for an additional two decades of service, as had been planned. Of the ten remaining carriers, only eight or fewer will be available for operational deployments. Withdrawing the Truman will make funding available for two new-build carriers. Addressing the situation when speaking to the Senate Armed Services Committee on March 14, Shanahan said it was a very difficult decision.

Upgraded HC-144B

The US Coast Guard has received an upgraded HC-144 medium-range surveillance aircraft at Air Station Corpus Christi, Texas according to a statement made by

the Coast Guard's 8th District on February 20, 2019.

The HC-144B upgrade improves the aircraft's extensive sensor capability, aiding the Coast Guard in maritime patrol, drug and migrant interdiction, disaster response, and search and rescue missions.

The Coast Guard is upgrading its HC-144A aircraft to improve mission effectiveness and situational awareness. Modified aircraft feature an updated cockpit control and display unit, navigation and equipment monitoring systems.

The Coast Guard is also integrating the US Navy's Minotaur mission system architecture across its fixed-wing aircraft fleet comprising HC-27As, HC-130Js and HC-144Bs. Fitted with Minotaur, a sophisticated command and control system, the aircraft incorporates surveillance and reconnaissance equipment to allow aircrews to gather and process surveillance information that can be transmitted to other platforms and units during flight.

E-2D Hawkeye BuNo 168595/601 assigned to Carrier Airborne Early Warning Squadron 121 (VAW-121) 'Bluetails' launches from the flight deck of USS Abraham Lincoln (CVN 72) during the carrier's composite training unit exercise with Carrier Strike Group 12.

Mass Communication Specialist 2nd Class Matt Herbst/US Navy





Airborne early warning KJ-500 30078 at Zhuhai in 2018. The fixed rotodome contains three active electronically scanned arrays arranged in a triangular configuration.
All images Chinese internet

China's latest special mission aircraft

By Andreas Rupprecht

FOR MANY years, the People's Liberation Army Air Force and Naval Aviation have operated specialised versions of the Y-8 and more recently the Y-9. Most remain unknown to the public because of the covert nature of their missions. More recently, several new types have entered service in increasing numbers, and with more information available.

The first special-mission version of the Y-8 was introduced in 1983 as the Y-8X (X for Xun or surveillance). The type was developed by the Shaanxi Aircraft Company (now Shaanxi Aircraft

Industry Corporation, part of the Xi'an Aircraft Corporation) to meet a request by the Naval Air Force for a long-range maritime surveillance aircraft.

Since the early part of this century, several dedicated variants were introduced, making the Y-8 and Y-9 series of aircraft the workhorse for special missions including electronic and signals intelligence, offensive electronic countermeasures, and even psychological warfare. Most were initiated under the so-called Gao Xin (high new) project.

Little information is available about the programme history of individual versions or their specific mission equipment. In most cases

little was known about the various projects until a new series of Y-8GX-versions were first seen. Despite sequential designations numbered from GX-1 to GX-12 they have not been seen in the same order. Adding further confusion to the already confusing sequential designation is the fact that – even if in the most modern variants clearly based on the new Y-9 transport – variants are still labelled Y-8GX and have an additional People's Liberation Army designation in which Y-8 or Y-9 is included.

Y-8GX-9 ELINT: Y-9XZ

In October 2012 it became clear that the Y-8GX-9 (also known as the Y-9XZ) was a

new psychological warfare variant based on the Y-9 platform. The aircraft is understood to have a new capability; hacking into enemy communication networks and therefore used to interrupt the internet traffic or to spread false information and create chaos through social networks by hacking into key web servers.

In operational livery, this variant has rarely been seen, but several entered PLAAF service by mid-2014 with the 20th Specialised Division replacing earlier Y-8XZs (GX-7s).

Y-8GX-10 AEW: KJ-500 and KH-500

Probably the best-known member of the New High family in service is the Y-8GX-10 or KJ-500 AEW. Under development by the SAAC since the late 2000s, this type is the next-generation medium-sized airborne and early warning and control platform.

In contrast to its predecessor, the KJ-200, the KJ-500 had its characteristic balance beam radar replaced by a more traditional fixed rotodome containing three active electronically scanned arrays arranged in a triangular configuration similar to that of the KJ-2000.

The radar is allegedly a new system designed by 38 Institute, which utilises the latest digital radar technology. During the GX-10's development programme, several radars and different radome shapes were evaluated

The sub-hunting Y-8GX-6 variant is based on the Y-8F-600 Category III Platform featuring a completely pressurized cabin. Aircraft 85192 is assigned to the 9th Division.



on the Y-8CE testbed; in addition to the three main antennas, an additional SATCOM antenna was also integrated into the top of the rotodome.

This variant also has an enlarged nose and tail radomes which likely house additional radar antennas to cover the forward and rear hemisphere. The KJ-500 features two rectangular bar shaped fairings housing ELINT antennas on both sides of the rear fuselage and missile approach warning sensors fitted aft of the cabin door and forward of the tail.

Ten KJ-500s are in service within the 26th Specialised Division, and confirmed by available imagery, the Naval Air Force is operating a similar number of KJ-500Hs (also known as HJ-500s) with two Naval Air Divisions. Still in production, recent imagery from February, taken at the factory in Hanzhong, Shaanxi province showed at least six new aircraft on the flight line.

A modernised variant designated the KJ-500A has been flying equipped with an aerial refuelling probe since March 2018.

Y-8GX-11 ECM and Y-8GX-12 ELINT

Very little information is known about the latest two variants only in existence since 2014-2015; the GX-11 (also known as the Y-9G) is reportedly a new ECM variant similar to the original GX-3 with the characteristic fuselage cheeks housing antennas designed to suppress enemy radar and communications.

Based on the Y-9 platform, the GX-11 features a new chin-mounted radome, and three large oval and rectangular shaped antenna panels along each side of the fuselage. Two plate antennas are installed on the vertical tailfin complemented by an array of blade antennas under the fuselage, and a small semi-spherical antenna underneath the wingtip.

An electronic intelligence gathering Y-8GX-9 (Y-9XZ).



Reportedly, two GX-11s were in service and operational with the 20th Specialised Division.

The most recent variant was first seen in April 2018 operating with the CFTE at Xi'an-Yanliang wearing the serial number 745.

Externally similar to the Y-9JZ (GX-8) flown by the Naval Air Force, this new variant has, to date, been referred to as the Y-8GX-12. It is rumoured to be a new ELINT-type for the PLAAF, which makes sense based on its nose configuration and two large rectangular-shaped antenna arrays fitted on both sides of its rear fuselage. Numerous other antennas are installed all over the fuselage, in the tail cone and on top of the vertical tail fin. Additionally, a SATCOM antenna is fitted on top of the mid-fuselage.

If the reported role is correct, the GX-12 may be the replacement type for the Y-8CB (GX-1) and may eventually be designated as Y-9DZ. The latest image of the factory airfield confirmed one GX-12 is being prepared for the delivery.

Y-8GX-6 ASW: Y-8Q or KQ-200

An exception to the sequential designation might be the Y-8GX-6 or Y-8Q ASW; quite possibly the most important special mission variant to date. However, even if the GX-6 is introduced into Naval Air Force service in the coming years, its early sequential number reflects that the variant has been under design and development for much longer.

The Y-8Q, also known as the KQ-200, is possibly the most eagerly awaited special mission variant for the Naval Air Force. Reportedly under development since 2007, this variant is based on the Y-8F-600 Category III Platform featuring a completely pressurized cabin. Powered by uprated WJ-6C turboprops (each rated at 5,100ehp) with JL-4 six-blade propellers, this aircraft also features small vertical stabilizers on the horizontal tail planes.

The configuration features a prominent bulbous radome housing a surface search radar, and most notably a distinctive MAD-boom. An

additional (to the baseline aircraft) multi-spectral turret housing a FLIR, CCD TV camera and laser rangefinder is fitted underneath the forward fuselage.

The KQ-200 is fitted with several radar warning receivers, missile approach warning sensors and blade antennas, and two large observation-windows in the aft fuselage.

Beyond its sensor fit, the most important addition feature for its ASW role, and a first for any Y-8 family variant, is an internal weapons bay positioned forward of the main-landing gear. Its weapons payload includes depth charges, light torpedoes (up to 8 Yu-7s or new Yu-11Ks) and perhaps up to four YJ-83K anti-ship missiles carried on underwing pylons.

Four sonobuoy launch tubes are positioned on the rear fuselage, aft of the internal weapons bay.

As a dedicated long-range ASW aircraft, the KQ-200 is understood to have a range of up to 2,700 nautical miles (5,000km) and a patrol endurance of up to 10 hours. The patroller allegedly features a secure datalink in order to be capable of coordinating with future carrier battle groups to extend the layer of defence against enemy submarines and small surface ships further away from the carrier and its accompanying battle group.

Two KQ-200 prototypes were first seen in November 2011; operational evaluation began in late 2013; first series –production aircraft was delivered in April 2015, and since then the type has entered widespread service; close to a dozen are assigned to three Naval Air Divisions.

The Naval Air Force's requirement for the KQ-200 is the largest of all the different special mission variants amounting to one dozen aircraft assigned to each Naval Theater Command.

Based on the Y-9 platform, the Y-8GX-11 features a new chin-mounted radome, and three large oval and rectangular shaped antenna panels along each side of the fuselage.



Upgraded Hawks, DA40 NGs and Aussie disposals

By Nigel Pittaway

IN NEWS from Australia this month, BAE Systems Australia has completed the 33rd and last Hawk Mk127 upgrade for the Royal Australian Air Force (RAAF), which has delivered a modernised training capability to better meet the training requirements for transition to fifth-generation fighters such as the Lockheed Martin F-35A Lightning II.

At the other end of the spectrum, the Air Force Cadets have begun receiving the powered DA40 light aircraft to supplement their fleet of gliders. One aircraft was displayed in public for the very first time at the recent Avalon Airshow.

Finally, disposal of former Australian Defence Force aircraft continues, with well-known types such as the Bell 206B-1 Kiowa and Pilatus PC-9/A falling under the auctioneer's hammer and the first two F/A-18A classic Hornets have been delivered to the Royal Canadian Air Force.

Hawk upgrade complete

BAE Systems Australia formally handed over the last Hawk Mk127, A27-24, to be upgraded under the Lead-In Fighter Capability Assurance Programme (LIFCAP) during a ceremony at Newcastle Airport on March 7, 2019.

Under the aegis of Project Air 5438, the LIFCAP upgrade has been delivered by BAE Systems Australia, in partnership with BAE Systems UK, the RAAF and the Defence Capability

Acquisition and Sustainment Group and industry partners CAE and Cubic Defence Applications. The work began in 2014 and was carried out at BAE System's facility at Newcastle Airport, across the runway from RAAF Williamtown – which is the home of the RAAF's 78 Wing and one of the two Hawk operating units, 76 Squadron.

The upgrade delivered on-budget and the final aircraft was handed back a month earlier than originally scheduled. The modernised aircraft are broadly similar to the RAF's Hawk T2 (Mk128) aircraft but retain their ability to employ live weapons. Royal Air Force Hawk T2s have only a simulated weapons capability. New software has been developed and certified in the Australian jets.

Director of Aerospace for BAE Systems Australia, Steve Drury, said: "The RAAF's Hawk fleet is now among the most capable in the world following this major upgrade. The modified aircraft provides the Air Force with a lead-in fighter that is comparable to the RAF's Hawk Advanced Jet Trainer and ensures the Australian Hawk aircraft is suitable for a fifth-generation air force, preparing pilots for the F-35."

Drury added: "The enduring partnership we have built in that time with 78 Wing, 76 Squadron (Williamtown), 79 Squadron (Pearce) and the Tactical Fighter Systems Programme Office is one we are extremely proud of and has helped deliver milestones for the Air Force like the completion of over 100,000 accident-free flying hours."

In related news, BAE Systems



Skyline Aviation's name and the helicopter's fire-fighting capacity are the brightest titles ever seen on former RAN S-70B-2 Seahawk N24-016.

Australia announced at Avalon Airshow on February 27, 2019, that it has won an AUD 245 million contract for the continuation of Hawk sustainment at Williamtown and Pearce until at least 2022, with further extensions available depending on performance.

DA40 NGs for Air Force Cadets

Also, at Avalon 2019, Minister for Defence Personnel Darren Chester announced the arrival of eight Diamond DA40 NG training aircraft for use by the Australian Air Force Cadets. One aircraft (VH-UEZ/02, msn 40N390) was featured in the static display at the show.

The aircraft have been leased from Airflite Pty Ltd and have been acquired to support safer and more advanced flight training for Cadets. Chester said Airflite has also been

awarded a ten-year contract for the provision of maintenance services for the fleet. The aircraft will be based at RAAF Bases Amberley (Queensland), Richmond (New South Wales) and Point Cook (Victoria), but will be regularly deployed to regional areas on weekends and during school holiday periods. Their acquisition was first announced by Chief of Air Force, Air Marshal 'Leo' Davies, in October 2018.

Announcement their delivery at Avalon on February 28, 2019, Minister Chester said: "I am pleased to announce the leasing of eight aircraft for exclusive use by the Australian Air Force Cadets. Over the next ten years these aircraft will provide a standardised flight training platform for aspiring young airmen and women, particularly those in regional areas."

Hawk Mk127 A27-01 is one of 33 aircraft upgraded by BAE Systems Australia under the Lead-In Fighter Capability Assurance Programme. The final aircraft was handed over to the RAAF on March 7, 2019.





Kiowas for sale at Avalon.

Aussie disposals

The recent recapitalisation of the Australian Defence Force's aircraft platforms has rendered several types redundant and several recent announcements have reported new homes for a number of aircraft.

Firstly, the initial two F/A-18A Hornets for the Royal Canadian Air Force were flown to Canadian Forces Base Cold Lake in Alberta on February 18, 2019, following their participation in Exercise Red Flag in the United States.

The two aircraft (A21-53 and A21-55) are the vanguard of 18 flyable aircraft purchased by Canada as a stop-gap strategy until a replacement fighter aircraft is selected. An additional seven aircraft are being acquired for spares.

To mark the occasion, Australian Defence Minister Christopher Pyne said: "These jets have served Australia very well and will now continue to make a positive contribution to the air combat capability of one of our closest allies."

Disposal of former RAAF Pilatus PC-9/As, Army Bell 206B-1 Kiowas and Navy Sikorsky S-70B-2 Seahawks were also in the public's view during Avalon 2019, with numerous aircraft in the static display.

Skyline Aviation Group has recently purchased 11 former Royal Australian Navy Seahawks and intends to convert them for fire-fighting operations. One helicopter (the former N24-016) was displayed in the static park to advertise the

helicopter's capabilities in the fire-fighting role.

Twenty-two former Army Kiowas and an initial batch of five former RAAF PC-9/As are being disposed of by Frontline Machinery and a number of each were on display at Avalon. The aircraft are the subject of an on-line auction process conducted by Gray's Online Auction House.

The PC-9/A is now being replaced by the PC-21 in RAAF service and the Roulettes aerobatic team flew its final display with the older aircraft at Avalon 2019. At least eight of the PC-9/As were flown from Avalon to RAAF Pearce in Western Australia immediately after the show. The fleet will be consolidated at Pearce until the last advanced training course finishes

in mid-year and they too will then be replaced by PC-21s. The PC-9/A will continue in service for a short period with the Aircraft Research and Development Unit (ARDU) at RAAF Edinburgh in South Australia and with 4 Squadron at RAAF Williamtown (NSW).

Finally, Lockheed AP-3C Orion A9-659 was formally handed over to the Australian War Memorial (AWM) at Avalon on February 28, 2019. The aircraft has been stored at the Victorian airport since being retired from service in June 2018, after accruing over 17,000 flying hours.

A9-659 will remain in storage at Avalon until new facilities are constructed in Canberra, home of the AWM, to house the aircraft.



Former RAAF Pilatus PC-9/A A23-059 dismantled and ready for sale at Avalon.



Australian Air Force Cadets' Diamond DA40 NG VH-UEZ/02 in the static display at Avalon.



More than 70 airlines now operate the three Boeing 787 variants, the 787-8 depicted here as well as the larger 787-9 and 787-10. *Boeing*

Nearly eight years after the Boeing 787 entered service, the Dreamliner is now an established part of airline operations with all three variants in service.

The baseline 787-8 entered service in October 2011 with launch operator All Nippon Airways, the longer-range 787-9 was introduced in August 2014 with Air New Zealand and finally the higher-capacity 787-10 debuted in March 2018 with Singapore Airlines (SIA).

Large network airlines, leisure operators and low-cost long-haul carriers all use the Dreamliner, which also holds the distinction of operating the first regular, scheduled, non-stop flights between the UK and Australia.

It is perhaps an understatement to say the 787 programme's early years did not run smoothly. The aircraft was repeatedly delayed during its development, with the type's introduction to service occurring more than three years later than initially planned.

As a report from Virginia-based aerospace industry analysts the Teal Group reflects: "Management placed entirely too much trust in the design, integration and financial capabilities of its risk-sharing partners. This

compounded the problems inherent in a very aggressive up-front programme schedule."

The negative headlines continued after the 787's operational debut. Glitches with the lithium ion (Li-ion) batteries powering the aircraft's electrical system, with incidents in early 2013 involving battery systems on Japan Airlines and All Nippon Airlines 787s, led to a US Federal Aviation Administration (FAA) airworthiness directive (AD) that grounded all 787s for five months that year.

The 787 returned to flight after Boeing developed further safety features for Li-ion battery systems, including an insulator to isolate electrically battery cells from each other and the battery case, more heat-resistant wire sleeving and wiring inside the battery and a stainless-steel enclosure to isolate the battery unit from the rest of the equipment in the electrical bays with a direct vent to carry battery vapours outside the aircraft.

The 787 has settled down since those troubled early days. A maturing production system means delivery rates are rising. Early 2019 saw the 787 operated by more than 70 airlines worldwide on dozens of routes, making the type an increasingly integral

part of commercial air transport. There has been an upturn in new business, too. Boeing picked up 109 orders for the aircraft in 2018, the best single year for Dreamliner sales since 2013.

What are the engine issues?

However, not everything has been completely rosy recently. There has been disruption for some operators in the last couple of years due to technical problems with the Rolls-Royce Trent 1000, one of two engine options on the 787 family (the other being the General Electric GEnx).

Issues related to the durability of parts have affected Trent 1000 Package C engines (the variant of the powerplant on the 787-9) and earlier-standard examples of Trent 1000 Package B engines (the variant powering the 787-8).

These issues are: fatigue cracking on fan blades in the intermediate pressure turbine (IPT); deterioration in the condition of fan blades in the engine's high-pressure turbine (HPT); deterioration in the condition of the intermediate pressure compressor (IPC) rotor blade; and deterioration in the IPC rotor blade seal.

787

*More orders,
more deliveries,
more technology.
Mark Broadbent
analyses the Boeing
787 Dreamliner
programme*



The problems led Rolls-Royce to implement precautionary inspections, service management actions and flight operations guidance on affected engines. The FAA and the European Aviation Safety Agency (EASA) also issued ADs mandating shorter maintenance inspection intervals and restrictions on the 787's extended-range twin-engine operations (ETOPS) clearances.

The AD for the Trent 1000 Package C reduced the inspection interval on the engine from every 200 flights to every 80 flights. Regulators also reduced the ETOPS diversion time for Package C engines from 330 minutes to 140 minutes, an especially significant limitation, because the 787-9 is expressly designed for long-range missions.

The result is that operators of Trent 1000-powered Dreamliners have had to cope with unscheduled engine maintenance to comply with the engine manufacturer's inspection requirements and the regulators' ADs. Aircraft-on-ground (AOG) rates have further increased as 787s affected by the problems have undergone rectification work to install the fixes Rolls-Royce has developed to enable the aircraft to resume operations with no limits.

According to the latest updates provided by Rolls-Royce, 386 in-service Package C engines and 166 in-service Package B powerplants are affected by the issues, meaning the Trent 1000s on a total of 193 787-9s and 83 787-8s require modification. Meanwhile, operators awaiting new aircraft have experienced delays to anticipated deliveries as Rolls-Royce works to integrate fixes into the production chain.

The issues have forced several operators to lease aircraft to cover for the capacity shortfall. For example, the 787-9's launch operator Air New Zealand leased Boeing 777-200s during 2018 to sub for its grounded 787s, although the airline said in an earnings call with investors on the 2017-2018 financial year the material impact had a "relatively minor" cost.

Virgin Atlantic Airways leased ex-Air Berlin Airbus A330-200s to cover for the capacity shortfall. Norwegian, which is using the 787-9 as the primary tool to grow its long-haul network, said in its full-year 2018 financial results there were "significant costs" related to the 787 engine issues. The carrier said it has reached a financial agreement with Rolls-Royce, adding its Dreamliner operation "is now running smoothly" and it sees the engine issues easing.

How are the engine issues being fixed?

The Trent 1000 issues have, as Rolls-Royce has noted, "happened at the same time, making it more challenging to resolve". How is the engine-maker responding?

The cracking on the IPT fan blade was caused by sulphidation, a form of chemical corrosion caused by pollutants in the air reacting with the high temperatures in the hot section of an engine. Rolls-Royce has developed a more corrosion-resistant protective coating for the blade.

The earlier-than-expected deterioration of HPT fan blades and IPC rotor blades was identified after it was found certain conditions caused the blades to vibrate and crack. A modified HPT fan blade design was introduced in October 2018 and a redesigned IPC rotor blade was certified by the FAA and EASA in January 2019. Relevant service bulletins issued to operators and Rolls-Royce said in January introducing the new blades as a retrofit "will take place on a phased basis as production ramps up".

The certification for the IPC rotor blade followed what the engine-maker called a "fast-paced programme" which began in

Singapore Airlines was the first to introduce the third Dreamliner version, the 787-10.
Singapore Airlines

June 2018 when the first revised blades were installed on a test engine at the company's Derby facility. Flight-testing of the new parts then took place on the Rolls-Royce Flying Test Bed, Boeing 747-236 N787RR (c/n 21966) in Tucson, Arizona. Rolls-Royce has said some Package C engines remain subject to ETOPS restrictions and an inspection regime continues to manage the IPC rotor blade issue.

A redesigned part is also the fix for the fourth issue, durability on the IPC rotor blade seal on high-cycle Package B engines (those in service the longest), which was identified following what Rolls-Royce calls a "similar inspection regime for the Package B as for the Package C" agreed with Boeing and regulators.

The first redesigned IPC rotor blade seal for the Package B engines is expected to be

delivered in 2019. Rolls-Royce stresses the redesigned part was not a response to an in-service event and is "a form of proactive maintenance to catch any issues" before they affect airline operations.

To help introduce all the fixes to the in-service fleet and achieve what Rolls-Royce calls "a zero AOG situation" for operators as soon as possible, the company has increased production capacity at its manufacturing facilities.

Rolls-Royce has also increased maintenance, repair and overhaul (MRO) capacity for Trent 1000s. For example, in 2018 Delta Air Lines' TechOps maintenance hub in Atlanta opened an Authorised Maintenance Centre (AMC) for several Rolls-Royce engine models, namely, the Trent 1000, Trent 700, Trent XWB and BR715. The AMC consists of

areas for engine assembly and disassembly, kitting out parts, work-in-progress, materials, supplies, life-limited parts and repairs.

Rolls-Royce's agreement with Delta for the AMC was announced in October 2015, therefore pre-dating the Trent 1000's problems; but with MRO capacity required to introduce the fixes for the engine, the centre's opening has clearly happened at a good time. The first engine inducted into the AMC was a Trent 1000 from a Virgin Atlantic 787-9.

Despite the increase in MRO capacity, in December 2018 Rolls-Royce admitted: "The number of AOG remains at a high level. We sincerely regret the disruption this has caused our customers. We are determined and confident that as we execute our plans, we will see a significant improvement in AOG as we progress through the first half of 2019.

Boeing 787 characteristics			
	787-8	787-9	787-10
Wingspan	197ft 3in (60.1m)	197ft 3in (60.1m)	197ft 3in (60.1m)
Length	186ft 1in (56.7m)	206ft 1in (62.8m)	224ft (68.2m)
Height	55ft 6in (16.9m)	55ft 10in (17.02m)	55ft 10in (17m)
Fuselage cross-section	18ft 10in (5.74m)	18ft 10in (5.74m)	18ft 10in (5.74m)
Max taxi weight	503,500lb (228,383kg)	561,500lb (254,692kg)	561,500lb (254,692kg)
Max take-off weight	502,500lb (227,930kg)	560,000lb (254,011kg)	560,000lb (254,011kg)
Max landing weight	380,000lb (172,365kg)	425,000lb (192,776kg)	445,000lb (201,849kg)
Max zero fuel weight	355,000lb (161,025kg)	400,000lb (181,436kg)	425,000lb (192,776kg)
Seats	242 dual-class (359 single-class)	290 dual-class (406 single-class)	330 dual-class (440 single-class)
Lower-deck cargo capacity	4,826ft ³ (136.7m ³) with space for 28 LD-3 containers	6,090ft ³ (172.4m ³) with space for 36 LD-3 containers	6,722ft ³ (191.4m ³) with space for 40 LD-3 containers
Usable fuel	33,340 US gallons (126,206 litres)	33,399 US gallons (126,429 litres)	33,384 US gallons (126,372 litres)
Cruise speed	Mach 0.85	Mach 0.85	Mach 0.85
Range	7,355 nautical miles (13,620km)	7,635 nautical miles (14,140km)	6,430 nautical miles (11,910km)
Engines	Two GE Aviation GEnx-1Bs or Rolls-Royce Trent 1000s	Two GE Aviation GEnx-1Bs or Rolls-Royce Trent 1000s	Two GE Aviation GEnx-1Bs or Rolls-Royce Trent 1000 TENS
Engine thrust	64,000lb (280kN)	71,000lb (320kN)	78,000lb (347kN) take-off thrust

Source: Boeing Airplane Characteristics for Airport Planning



"Pilots find the aircraft's handling to be agile and responsive."

Singapore Airlines

"We have a robust solution in place to eliminate these issues from the fleet as quickly as possible. We expect the number of AOG to reduce progressively through the course of 2019. Ultimately, we must eliminate this problem altogether and we are already redesigning specific parts of the compressor and early parts are already in manufacture."

Rolls-Royce emphasised no durability issues have been discovered with parts on the Trent 1000 TEN, the variant of the Trent 1000 powering the 787-10 and that has been unaffected by the engine issues. However, the company said it is "taking precautionary action to design and introduce a new standard of blade to this engine" later in 2019. The company also notes the Trent 1000 TEN is "subject to similar guidance as the authorities seek to harmonise the regulations for all Trent 1000 models. As new standard blades are installed, full ETOPS capability is restored."

Rolls-Royce said when presenting its full-year 2018 results in February 2019 that the exceptional charge on the Trent 1000 issues increased from £554 million at the half-year point (June 2018) to £790 million for the full year, which the company said "reflects a contribution to customer disruption costs greater than those anticipated at the half year . . . Total cash costs [2017–2022] to resolve Trent 1000 issues [are] £100 million higher than earlier estimates, higher disruption partly mitigated by good progress on reducing shop visit costs."

The company's results said the 2019 full-year cash impact on its Civil Aerospace unit of the Trent 1000 issues is expected to be around £450 million, "before declining by at least £100 million in 2020, and reducing materially thereafter".



The 787's modern flight deck is praised by its operators. *Alexander Mishin/AirTeamImages*

Flying the 787

Boeing says a key strength of the 787 for operators is the aircraft's modern, advanced flight deck. Pilots clearly appreciate it, judging from comments provided to AIR International by several Dreamliner operators.

Singapore Airlines, which now has a full year of Dreamliner operations under its belt after putting its initial 787-10s into service in March 2018, told AIR International: "The electronic checklist [ECL] is an extremely useful tool for pilots, guiding them as they carry out the necessary procedures. It replaces the conventional paper checklist and pilots can now access checklist electronically to configure the aircraft systems for various stages of flight and conditions. In addition, the ECL minimises any mismanagement of lapses and omission of checklist items."

"The Boeing 787's flight deck features large landscape-format liquid crystal display screens and a vertical situational display. Pilots find the aircraft's handling to be agile and responsive. Operational excellence gained from one aircraft type can be seamlessly transferred to another with the high degree of cockpit commonality between the 787 and 777. Our cabin crew are trained in multiple aircraft fleets. Their experience in operating the 777 is certainly of benefit when they are cross-trained on the 787-10s."

TUI Airways told us: "The flight deck is large and comfortable and very quiet compared to [other] aircraft. From a pilot's perspective, the aircraft is straightforward to operate and provides the pilot with a number of flight envelope protections adding to the safety of flight. The ECL provides the pilot with a simple and immediately accessible means of checklist completion. Some items in checklists are closed loop, which means that the system detects the position of a switch, lever or system and closes the loop automatically when an action has been taken. This means there are less items for the pilots to check."

"Dreamliners are equipped with dual HUDs [head-up displays] which provide the pilots with flight information in their line of sight, meaning that there is less of a requirement to look in. Full-time autothrottle capability and asymmetry compensation through the flight controls means that engine out handling is straightforward for the pilots."



Where do orders and deliveries stand?

Despite the Trent 1000 issues, the 787 programme is overall in what the Teal Group analysts call "positive territory". As the consultancy notes, the 787 is the fastest-selling widebody airliner ever. Boeing's orders and deliveries data shows that, by early March 2019, total 787 family orders stood at 1,403 aircraft since the programme's launch in 2004. The total comprised 444 787-8s, 790 787-9s and 169 787-10s.

There was a flurry of orders when the 787 was launched and for a few years thereafter as customers rushed to secure delivery slots for an aircraft that Boeing says offers savings of 20% in fuel burn, 30% in maintenance

costs and 15% in operating costs compared to earlier-generation aircraft in its size class.

Business plateaued and then fell away in the late 2000s and early 2010s as delivery dates slipped due to the various development delays affecting the programme. From a single-year sales high of 369 aircraft in 2007, the year of the 787-8's roll-out, orders slumped to just 13 jets in 2011.

Annual orders for the 787 have rebounded more recently, rising from 41 in 2014 through annual figures of 71 (2015), 58 (2016) and 94 (2017). These totals were followed by 110 orders in 2018, the first year since 2013 Boeing recorded three-digit annual sales for the aircraft.

Last year's orders included repeat business from American Airlines (for 47 more examples, split between 22 787-8s and 25 787-9s) and United Airlines (13 more). There were new customers in the form of Turkish Airlines (up to 30 787-9s) and Hawaiian Airlines (six 787-9s), the latter switching a fleet replacement purchase from the competing Airbus A330neo. By March 2019, Boeing had delivered 360 787-8s (leaving 84 orders unfilled), 406 787-9s (384 unfilled) and 15 787-10s (154 unfilled).

Boeing has ramped-up 787 production in recent years. The Teal Group has said if an airliner's popularity is measured by its build rate, the 787 is the single most popular twin-aisle widebody aircraft ever. Twelve are now produced every month by Boeing at the two final assembly sites for the aircraft, Everett in Washington and North Charleston in South Dakota. By comparison, Airbus' current rate for the A330 is six per month.

Monthly 787 output is set to increase again, to 14 per month. Boeing Chairman Dennis Muilenburg confirmed during a late-January 2019 investors' call this transition will happen during the second quarter of this year, taking Dreamliner production to 168 units a year.

Producing more aircraft matters for original equipment manufacturers (OEMs) because it means more airlines make delivery payments. The rate increases on the 787 therefore reflect not only the size of the type's orders backlog and a maturing production system, but also the Dreamliner's importance as a source of revenue for the OEM.

How do airlines use the 787?

With so many Dreamliners now in service, it is worth considering exactly how airlines use the aircraft.

The 787's key advantage for operators is its twin-engine fuel efficiency and range lets

ABOVE: Rolls-Royce says it is overcoming issues with the Trent 1000 which have caused disruption for Dreamliner operators in recent years. *Rolls-Royce*

BELOW: Virgin Atlantic Airways 787-9 G-VCRU (c/n 37972) captured on departure from Heathrow. *Ian Harding*



carriers start medium to long-haul routes services that would have been unsustainable with older, less efficient equipment.

This has led to the most significant impact of the 787: its role in airlines' network development. Boeing says more than 200 new city-pair connections have been opened using the Dreamliner since the type entered service.

As the airline industry consultant John Strickland from JLS Consulting, a former network planner, told AIR International: "Airlines can test out routes in a much lower-risk way. One, they're not having to put in a 747, A380 or even a 777 [on to the route], so the [fewer] seats you put in, the less you have to discount to fill the plane. Two, they're burning less fuel.

"The 787 gives the best of both worlds, opportunity and risk reduction. Any aircraft that brings you more efficiency, reduces your risk and exposure in the marketplace and increases your opportunity is an ideal combination."

Many of the network airlines who make up the bulk of 787 customers have used Dreamliners to open new services. Most strikingly, Qantas uses 787-9s on a direct Perth-Heathrow service, the first scheduled non-stop air route between Europe and Australia. Meanwhile, North American and Asian carriers use 787s on non-stops across the Pacific from the US West Coast, and British Airways has used 787s to start new services from Heathrow to secondary destinations with thinner demand, such as Hyderabad, Houston, Montreal, Muscat and Nashville, among others. BA says the Dreamliner gives the carrier the right configuration and capacity to go into new markets and chase new profitability opportunities.



Smaller operators such as TUI also operate 787s. This 787-9, G-TUIM (c/n 62742), is pictured at Manchester in February 2019.
Enda Burke/AirTeamImages

New routes with the 787 are not just the domain of the largest network airlines. TUI Airways (formerly Thomson Airways) was the first UK carrier to operate 787s in 2013. A spokesperson told AIR International: "The Dreamliner has enabled TUI Airways to fly directly from the UK to the Far East, with routes to Thailand and Vietnam, and also to Puerto Vallarta and Los Cabos on the Pacific coast of Mexico. We're often the first and only UK carrier to open up some of these exciting new direct routes."

Dreamliners also fly with some of the new long-haul, low-cost airlines that have emerged in recent years. As well as Norwegian, there is Singapore-based Scoot (ten 787-8s and eight 787-9s) and the Canadian carrier WestJet, which recently started flying 787-9s (it has ordered ten). A South Korean start-up carrier called Premia, which describes itself as a hybrid between a low-cost airline and a full-service carrier, has also picked the 787-9.



"Any aircraft that brings more efficiency, reduces risk and increases opportunity is an ideal combination."

John Strickland, JLS Consulting

The 787's economics mean the type is useful beyond network development, as it can improve the performance of existing routes in an airline's network by replacing less-efficient older aircraft. SIA told AIR International that as the airline receives more 787-10s over the coming years the aircraft will be, "progressively deployed on more and more routes, replacing Airbus A330s and Boeing 777s as they are retired".

Smaller operators, such as TUI, primarily serving leisure markets also similarly benefit from opportunities to operate routes more efficiently. The TUI spokesperson told AIR International: "We had high expectations for the 787 with regard to its performance and efficiency, and we are extremely satisfied with it. The 787 operates a range of short, mid and long-haul routes from the UK in summer. In

winter, it operates only long-haul routes from both the UK and Scandinavia. The composite structure and revolutionary engines make the 787 extremely fuel efficient, and its ability to operate such a wide range of routes means it's a huge asset in our fleet."

This ability to operate different routes is another of the 787's benefits. All airlines, especially large network carriers, must account for numerous factors (macroeconomics, seasonal travel patterns, competitors' schedules) when planning routes to ensure they put in the correct number of seats to maximise returns.

This means they appreciate an ability to move around capacity to use an appropriately-sized aircraft and help a route run profitably. With the 787-8's 242 seats (two-class) and 7,355 nautical miles

(13,620km) range, the 787-9's 290 seats and 7,635 nautical miles (14,140km) range and the 787-10's 330 seats and 6,430 nautical miles (11,910km) range, the Dreamliner variants offer complementary seat and range capabilities while providing single-type commonality.

Strickland explained: "You don't have the complexity of different aircraft types with different spares holdings. Flight crews can operate across all variants. You can adjust your allocation of aircraft according to different route strengths, and even make some on-the-day, last-minute or ad hoc changes without changing the type or any of the parameters around the operation."

In short, the 787 variants provide different strings in an airline's network planning bow. A 787-8 can

Qantas flies its 787-9s on routes including Perth-Heathrow, the first direct air service between Australia and Europe.

Qantas

Non-stop to Australia

One of the most notable routes the Boeing 787 flies is the first-ever regular non-stop service between Europe and Australia, a route from Perth to London Heathrow, operated by Qantas' fleet of 787-9s since December 2017. At around 17 hours long, depending on winds, the daily non-stop service covers 7,828 nautical miles (14,498km), making it the longest yet served with a 787.

Flight QF9 is scheduled to depart Perth at 18:45hrs local and arrive into Heathrow at 05:05hrs local the next day, with the return flight QF10 leaving Heathrow at 13:15hrs local and landing in Perth at 13:00hrs local the following day. After turnaround in Perth, the flight continues on to Melbourne. The service is operated by four pilots and 12 cabin crew.

The flight is popular, with a Qantas spokesperson telling AIR International: "We're consistently seeing load factors in the 90s" (i.e. 90%-plus). The 787-9 itself is, the spokesperson added, "exceeding our expectations".

The spokesperson said: "For Qantas, the capability and operating economics of the 787-9 means it is the perfect aircraft to carry out the first non-stop flight between Australia and the UK. The route continues to be very popular with our customers because of the incredible benefits the non-stop service offers and the enhanced cabin features, which really help minimise jetlag."

Complementing the systems aboard the 787, Qantas has introduced a new lounge in Perth with what it calls "therapy showers" containing "a special light that can help adjust to the destination time zone, increase alertness and combat the effects of jetlag".

Qantas also operates its 787-9s to the United States on its Melbourne-Los Angeles, Melbourne-San Francisco and Brisbane-Los Angeles-New York JFK and Brisbane-Los Angeles routes. The airline's Dreamliners also serve Hong Kong from Brisbane and Melbourne and, from late March 2019, Sydney.

Qantas said: "We're clearly seeing the strong foundations of building a hub in Western Australia, so we're excited about the future potential. We would be looking at other destinations, like Paris and Frankfurt direct to Perth, and new routes from Brisbane."

"The 787-9 is the perfect aircraft to carry out the first non-stop flight between Australia and the UK."

Qantas

be used to try out a route, a 787-9 to fly long range and a 787-10 to add capacity where there is a demand for more seats and revenue cargo.

Many Dreamliner customers operate multiple variants. To choose just a few examples, as of early March 2019 All Nippon Airways was using a mix of 36 787-8s and 30 787-9s, American Airlines 20 787-8s and 21 787-9s, BA 12 787-8s and 18 787-9s, Etihad Airways 23 787-9s and five 787-10s, and LATAM ten 787-8s and eight 787-9s.

United Airlines is the first Dreamliner customer to use all three variants. As of early March 2019, it had 12 787-8s, 25 787-9s and four 787-10s in its fleet (with 13 more 787-9s and ten more 787-10s to come). BA will also use all three models from 2020 when it adds the first of 12 787-10s.

What about the 787's future?

The widebody airliner market might be viewed as one amorphous whole, but there are, in fact, different niches within the niche. The 787-8 sits at the lower end of the market, with around 250 seats, where it competes with the Airbus A330-800. The 787-9 sits in the 250-300 seats area competing with the A330-900 and the 787-10 is in the 300-to-350 seats category competing with the A350-900. (The area of 350-plus seats occupied by the A350-1000 and the 777/777X is separate to the categories covered by the 787.)

With the 787 variants established in airline operations, Boeing Commercial Airplanes' product development focus has shifted to other projects, principally the 777X, but also the studies into a new

mid-market aircraft (NMA), dubbed the 797 by some (although not by Boeing itself), a possible new aircraft in the 'middle of the market' slotting into Boeing's product portfolio beneath the 787-8 and above the 737 MAX variants.

Although big developments with the 787 itself are unlikely in the short term, this doesn't mean activity in the market more widely will not impact on the Dreamliner. The new-generation A330 variants that compete with the 787-8 and 787-9 have sold pretty slowly so far, with the A330-800 having just eight orders and the A330-900 variant 230 by early March. This could mean the 787-8 and 787-9 dominate in their respective areas of the market. The Teal Group says the market has the potential for 3,000 aircraft over 20 years.



There is speculation Airbus could re-engine the A350-900 in the 2020s using new-generation turbofans, but Teal Group Vice-President Analysis Richard Aboulafia told AIR International: "All three engine primes are really too busy right now, and for the next few years, to offer an upgrade."

This might help the 787, he feels, "as it delays A350 re-engining". Separately, Aboulafia thinks: "Boeing might choose to redesign the 787-8, to reduce weight and obtain commonality with the larger variants."

The NMA/797 could also have an influence if it were launched. As Boeing previously confirmed to AIR International, the NMA studies are looking at an aircraft with 220 to 270 seats and 5,000 nautical miles (9,260km) range – close to the 787-8 in terms of seating, if not in range. Boeing has already said the technologies on the 787 will also be leveraged if it develops an NMA/797.

How are the 787's systems evolving?

The future direction of the widebody market and the ways it will influence the 787 are yet

to play out, but in the interim Boeing is not sitting still on the Dreamliner.

Big data has attracted more attention in numerous industries in the last few years. The term, broadly speaking, refers to the gathering of information generated by connected hardware and software and how businesses then use that information to help their operations.

With aircraft, their engines and systems generating huge volumes of data, this is unsurprisingly a pertinent issue in aerospace. In recent years, OEMs have introduced new digital analytics to provide insights into aircraft health, fleet performance and flight operations, and diagnostic/prognostic tools to support maintenance, engineering, supply chains and inventory.

A spokesperson from Boeing's Global Services division told AIR International: "Newer aircraft are generating a lot more data. Boeing's 787 creates over a terabyte of data during a typical flight. This data generates more opportunities to apply analytics in a way that uncovers greater efficiency and allows proactive approaches in aircraft maintenance operations."

Boeing Commercial Airplanes' big data products are united under a brand called AnalytX, which powers various maintenance applications designed to optimise and improve aircraft usage. One app is Airplane Health Management (AHM), which uses predictive alerts to let operators evaluate two million parameters on the aircraft in real time, helping them schedule maintenance and minimise disruptions.

The AHM app is available across all Boeing commercial aircraft, not just the 787, but Boeing Global Services told AIR International one undisclosed customer has reduced turnaround times on its 787s by an average of 10% by using AHM. Qantas, United Airlines and Korean Air Lines are among 787 operators who have announced their use of AHM for their Dreamliners.

Another AnalytX-powered app on the 787 is Fuel Dashboard, which lets operators view and analyse fuel usage and adjust operations to improve efficiency. Boeing says the app, "routinely helps customers save between 4% and 7% on fuel costs, equating to millions of dollars in fuel savings and lower fuel emissions".

China Southern Airlines 787-9 B-1168 (c/n 38797) was the 787th Dreamliner to be delivered. Boeing



"Data generates more opportunities to uncover greater efficiency."

Boeing Global Services

There is a separate app for crew optimisation, designed to assist airlines in efficient rostering and crew planning based on real-time data to reduce operating costs by an average of 3%–7%.

Boeing Global Services said the company's resources, global presence and customer relationships gives it, "a unique ability to positively disrupt the market and generate a robust pipeline of products and services for 787 customers".

Further aftermarket support for the 787 provided by Boeing includes a Landing Gear Exchange programme for managing landing gear overhauls. Following on from Boeing's history of similar programmes, 787 operators can exchange landing gear that needs to be repaired or overhauled for another set of certified landing gear from a pool maintained by Boeing, eliminating the need for operators to contract, schedule and manage the overhaul process themselves.

Boeing also provides 787 type rating training at campuses that offer a mix of web learning, fixed based and full flight simulation. Full-motion 787 simulators are located at London Gatwick, Miami, Shanghai and Singapore.

On board

One of the much-heralded aspects of the 787 when it was launched was comfort for passengers thanks to the lower cabin altitude, the onboard filtration system and inlets drawing fresh air from the outside for air conditioning, LED mood lighting and larger windows.

According to TUI: "The cabin altitude is lower than on a conventional aircraft and the humidity is controlled to provide a fresher feel after the flight. Also, the windows on the aircraft are 30% larger than the conventional aircraft, making the cabin light and airy. There is no doubt that customers choose to fly on the Dreamliner because of these features."

Another big aspect of the flying experience for passengers is in-flight entertainment and connectivity (IFE&C). Widely available Wi-Fi, smartphones and other connected devices have raised travellers' expectations on connectivity and content and unsurprisingly airlines introducing the 787 ensure their Dreamliners are equipped with good IFE&C offerings.

For example, SIA 787-10s have an IFE&C system based around Panasonic's eX3 system which the airline claims is a "personalised interactive experience" enabling flyers to create playlists of movies and TV shows, receive media recommendations based on personal preferences and viewing history, and customise and search for entertainment options. SIA told AIR International it has "received positive feedback from our customers about their in-flight experience" since introducing the 787-10.

Virgin Atlantic 787-9s meanwhile are equipped with the Vera Touch 2, which offers 11in (279mm) seatback screens in Upper Class (the airline's name for its first class product) and premium economy and 9in (228mm) screens for economy, with over 500 hours of entertainment (approximately 80 movies, 78 hours of TV and over 305 albums) with a shuffle option when listening to music and connect their own devices to the seatback system. All aircraft have exConnect, Ku Band Wi-Fi from Panasonic. Customers with laptops, tablets or mobile phones can connect their devices to the wireless onboard internet. **AI**



The announcement by GE Aviation on February 27 that its XA100 variable-cycle fighter engine design had completed—to the satisfaction of the US Air Force Research

Laboratory (AFRL)—the detailed-design process under the US Air Force's Adaptive Engine Transition Program (AETP) means GE is cleared to manufacture all the parts required to build and test XA100 engines.

David Tweedie, GE Aviation's general manager for advanced combat engines, told AIR International that the detailed-design process involved GE passing "a staggered set of detailed-design reviews (DDRs) over the course of time. That activity was concentrated in 2018." GE completed the last of the detailed-design reviews before the end of last year, "so at this point there are no further customer DD Rs planned as part of the baseline programme. Now we are pivoting to focus on getting the engine manufactured and tested. It's time for the engineers to put their pencils down, for parts to come in, and let's go get the data."

In completing the detailed design of the XA100, according to Tweedie, the company has moved on to a new phase of development from the primary technology-development effort in which it has been involved for the past 12 years to design and mature a variable-cycle fighter engine based on an adaptive-cycle fan design. Its XA100 design having been approved by the US Air Force, GE has now embarked on the final push to complete Phase 1 of the two-phase AETP programme. This push represents the final maturation

of adaptive-cycle fan engine development to the point where an XA100-sized engine can be placed quickly—and with very little technological and design risk—into volume production if required, said Tweedie.

This final push will involve GE Aviation manufacturing the parts needed for three complete XA100 engines that it will build and test by 2021, and GE testing the three engines fully and providing the resulting data to the AFRL. Also, highly importantly, throughout the process the company will be required to demonstrate to the satisfaction of the US Air Force Life Cycle Management Center (AFLCMC, which is overseeing the AETP programme) that GE can reliably manufacture the quantity and quality of parts needed for volume production of the XA100 should the US Air Force decide it requires that.

Along with Pratt & Whitney's XA101 variable-cycle engine, GE Aviation's XA100 is one of two adaptive-cycle fan engine designs competing for what may eventually be a decision by the US Air Force to order just one variable-cycle fighter-engine design into production based on the service's findings from AETP Phase 1. In 2016, the AFLCMC awarded each of the two companies a \$1 billion, five-year R&D contract under AETP Phase 1 so the US Air Force could choose a potential winner from the XA100 and XA101 and order it into production during the first half of the 2020s.

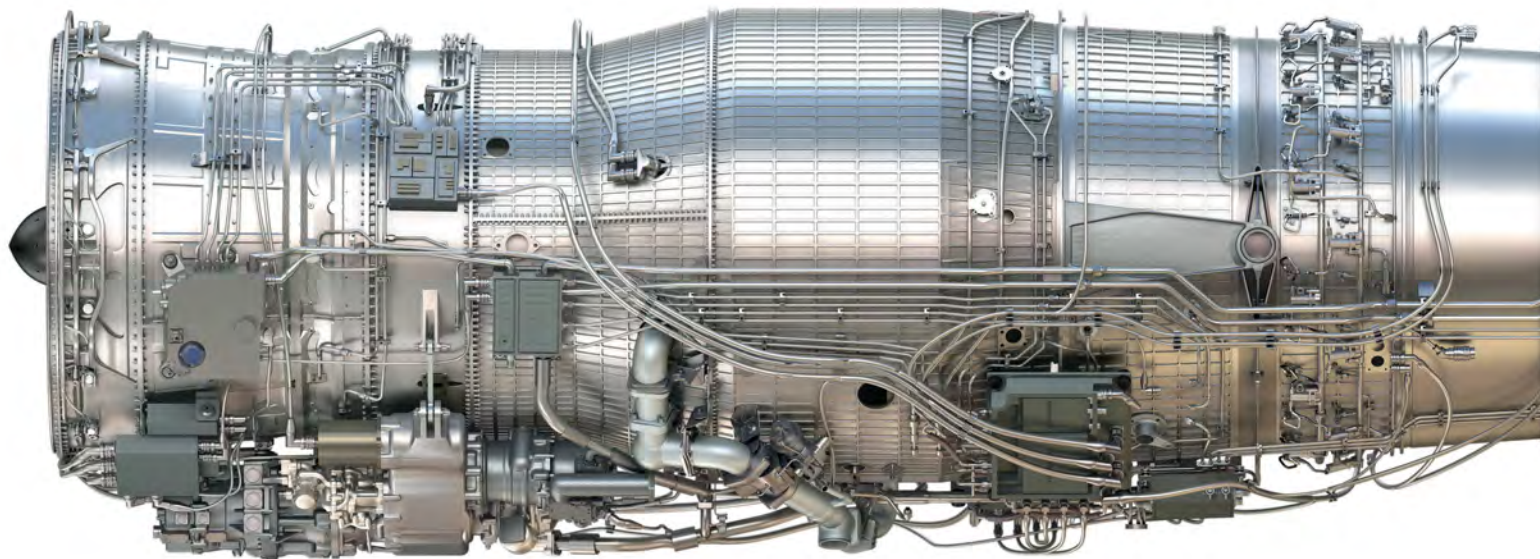
As finally became clear publicly in mid-2018, the US Air Force specifically had in mind a potential decision to re-engine the Lockheed F-35 from about 2025 onwards, partly as a

result of the known thermal-management challenges the F-35 has today in combination with its existing F135 engine. To that end, the AFLCMC specified that not only must the XA100 and XA101 fit the space within the F-35 that the F135 occupies today, but it also required the competitors' variable-cycle engines to demonstrate a 10% maximum-thrust increase over the F135, along with a 25% fuel-efficiency improvement and the capability to give the F-35 a 20% range increase.

Also specified, but not in a manner relayed publicly, is that the AETP Phase 1 competitors must provide the F-35 with substantially, perhaps very dramatically, improved thermal-management capabilities. Of necessity, those thermal-management capability improvements require that both AETP Phase 1 competitors work very closely with F-35 airframe manufacturer Lockheed Martin to integrate the airframe and its systems with the engine and its systems to an extremely high degree.

However, should either Pratt & Whitney's or GE Aviation's respective AETP Phase 1 engine design lose the AETP Phase 1 competition and not be ordered for volume production, the losing company may yet retain hope that its AETP R&D work may still end up in a production contract. This is because in 2018 the AFLC awarded each of the two companies a new \$437 million contract to pursue R&D work under a new Phase 2 of the AETP programme, which is aimed at reducing — "burning down", in the words of Tweedie's recently retired predecessor Dan McCormick — the technological risk associated with development and manufacturing of variable-

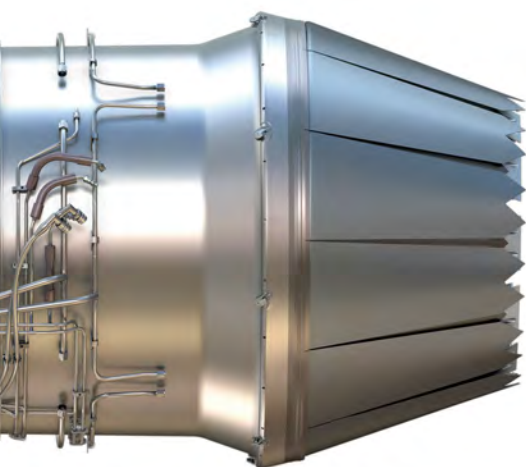
GE Aviation's future fighter engine





GE Aviation's first fully adaptive-cycle fan engine in test. This engine was developed under the US Air Force's ADVENT research and development programme which ran between 2007 and 2012.

Completion by GE Aviation of the detailed design process for its adaptive-cycle fan engine signals a switch from technology development to ensuring manufacturing readiness, reports Chris Kjelgaard



GE Aviation's XA100 adaptive-cycle engine.

cycle engines sized in terms of thrust, weight and dimensions to power types or categories of future US Air Force combat aircraft other than the F-35.

So far the end date of AETP Phase 2 remains publicly unspecified; and Tweedie said the classified nature of the new R&D phase prevents him from indicating if it involves a preliminary design review and/or detailed design review. Nor is he prepared to discuss the potential timing, sequencing and details of any engine-module or full-engine testing programme that the AFLCMC may be requiring GE Aviation and P&W to perform under AETP Phase 2. All that is known definitely about the timing of the second phase of AETP is that it will run for an unspecified amount of time beyond the end of AETP Phase 1—but probably not more than a year or two beyond.

Completing phase 1

Any development programme for a modern military or commercial jet engine requires a complex, carefully timed staggering of the releases to parts suppliers of the detailed technical drawings for the hundreds of types of parts the engine-design contains. This is vital for allowing all the parts to be manufactured at the right time and in the right sequence to enable final assembly of test engines to take place, according to Tweedie. Release of the initial-design drawings for the longest-lead time parts comes first and the manufacturer continues to work on detailed design of long- and short-lead-time parts alike after those initial drawing releases.

For the XA100, "now, essentially, we're fully released," said Tweedie. "The engineers are putting the final [part] dimensions on drawings and [they] are clear to release all the drawings to the supply chain. We have released much of them and it's just a matter of releasing the drawings for the short-lead-time hardware."

By the 2000s, GE Aviation's long history of developing turbofan engines—Tweedie calls them "mixed-flow engines"—over nearly 60 years since it developed the CJ805-23 in 1960, the TF39 in 1968 and the F101 in 1970 eventually "told us we were pushing up against some empirical limits" in terms of the performance levels which can be obtained from a turbofan fighter engine, he said. However, GE's development of the first fully adaptive-cycle fan engine under the US Air Force's 2007-2012 ADVENT R&D programme persuaded it—and the US Air Force—that variable-cycle engines could create a paradigm shift in fighter-engine performance.

The company's subsequent learnings from the 2012-2016 Adaptive Engine Technology Development (AETD) and AETP programmes—both tendered and conducted with Pratt & Whitney in competition—told GE Aviation that by the detail-design stage of AETP Phase 1, "we liked our [adaptive-cycle fan] design the way it was", said Tweedie. Accordingly, throughout AETP Phase 1, GE Aviation has focused not only on fine-tuning its existing materials and aerodynamic design technologies in order to create a functioning and technologically low-risk XA100, but also in maturing its manufacturing technologies.



The US Air Force Life Cycle Management Center has specified that the GE Aviation XA100 and Pratt & Whitney XA101 must fit in the space within the F-35 currently occupied by the F135 turbofan engine.

Senior Airman Alexander Cook/US Air Force

"We have got the set of [required] technologies from ADVENT, AETD and AETP, but we still are going through some learning as we go through detailed manufacture," said Tweedie. This particularly applies to the manufacturing technologies involved in producing parts made of highly heat-resistant ceramic matrix composite materials and parts made using additive-manufacturing—popularly labelled "3D printing"—techniques. GE has made extensive use of both kinds of parts in the XA100 and the engine also incorporates parts made of polymer matrix composite materials, also made using advanced manufacturing techniques.

"Part of the learning is forcing yourself to make parts of sufficient quality to go in the engine," said Tweedie. From the US Air Force's point of view, the whole point of the AETP programme is to burn down manufacturing risk, which it and its industry partners describe systematically by means of a manufacturing readiness level (MRL) scale of defined technological and manufacturing capabilities. The scale's top step, MRL 6, is the fully continuing capability to sustain production at the fully required quality and at the fully required rate of any product or technology the US Air Force has ordered.

For the US Air Force, the whole point of the ADVENT, AETD and AETP R&D programmes has been to have a suitable engine — or

series of engines — fully available for its future combat aircraft when they are eventually built, said Tweedie. "We don't want to create [a situation where already-manufactured] aircraft have holes that need engines. Now that we understand the design system, when we commit to time, budget and performance, we can hit it with low risk," he said. "That includes the ability to manufacture in [the] quality, quantity and at a scale ... that is mature enough for us to have high confidence we can deliver quality hardware for these assets. By means of ADVENT, AETD and AETP, "we've gone from MRL 3 to 4 to 5 and now ... this is the final step, to go from MRL 5 to MRL 6, for many of the technologies."

Air Force thinking

Although the AETP R&D programme began in 2016 and specified an adaptive-cycle fan engine which was of the same dimensions as the F135 powering the F-35, the US Air Force and its two AETP contractors said at that time the specification merely served as a convenient reference point for GE Aviation and P&W to assist them in developing their respective AETP Phase 1 engines.

Indeed, each of the two contractors was allowed to inform the AFLCMC of its preference regarding the AETP engine's physical size and reportedly each asked to be able to develop an F-35-compatible engine.

Not until two years later did GE Aviation, in the person of then-GM advanced combat engines Dan McCormick, first confirm publicly—with the US Air Force's permission—that the AFLCMC had deliberately specified the AETP Phase 1 engine so that it could potentially serve as an F135 replacement.

Asked by AIR International why the US Air Force took this course, Tweedie said it had not wanted at the time to focus public attention specifically on a potential re-engining of the F-35 because the service had believed strongly for years—and had said publicly—that it believed variable-cycle engines would be fundamentally important for all of its future fighter aircraft. When the AETD programme began in 2012, the US Congress had asked about the purpose of the programme and even then the US Air Force indicated it thought adaptive-cycle engines represented the future for all of its fighter types, according to Tweedie.

Before the AETP programme began in 2016, the service had indicated the 10% thrust-increase requirement and the 25% fuel-efficiency improvement "would be foundational for the Air Force to have superiority against adversaries," Tweedie said. "Neither in words nor actions has the Air Force done or shown anything other than what it said then — this is the future for all our products."

The US Air Force has always had valid reasons for this belief, said Tweedie, adding that the most important one is illustrated by the concept of “technology S-curves”. When performance improvements generated as a result of the introduction of a major new technology are graphed against the time elapsed since the technology is first applied, the graph line usually exhibits a pronounced ‘S’ shape.

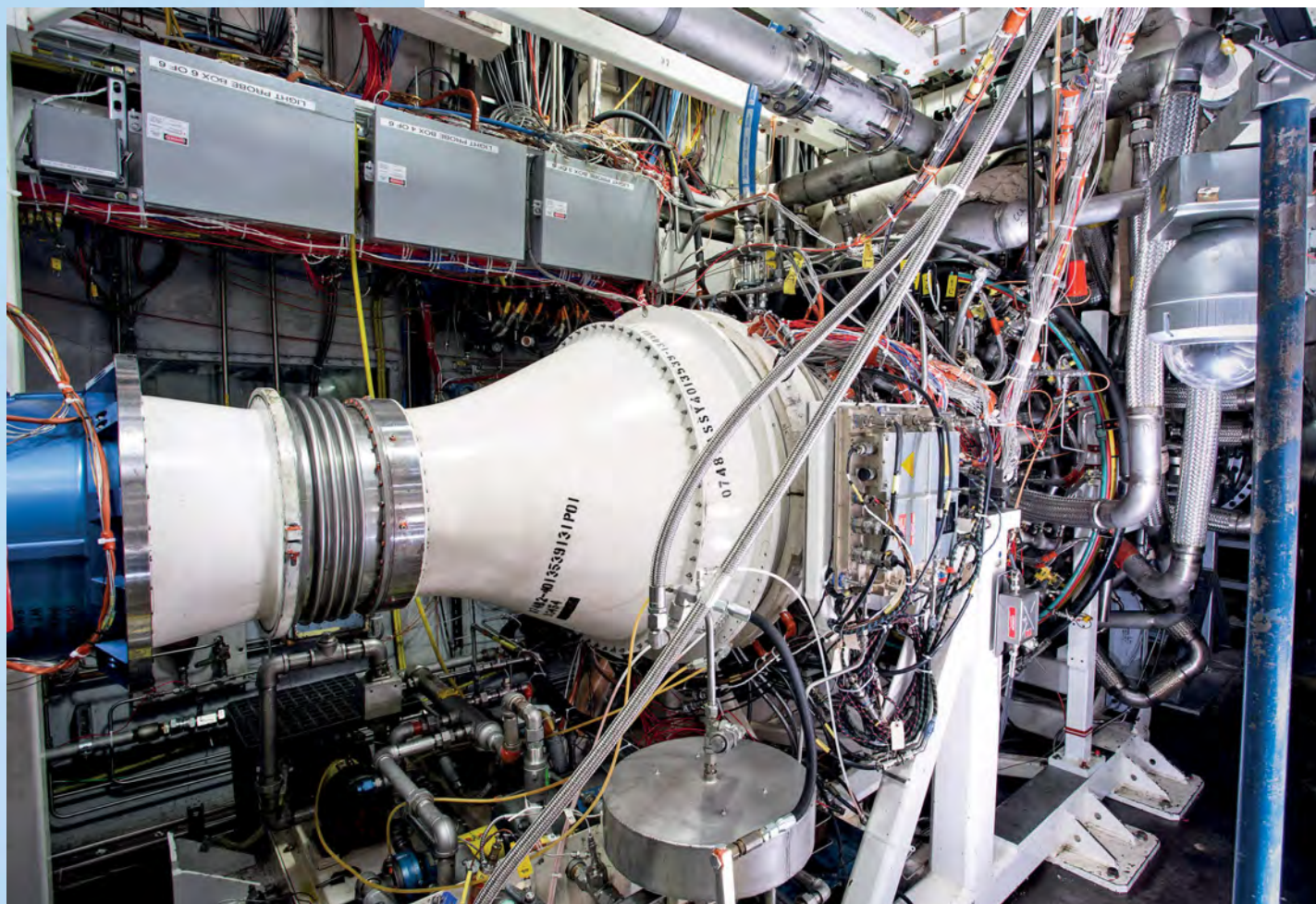
This ‘S’ shaped line occurs because, initially, the level of performance improvement is only gradual, as manufacturers begin to explore how the new technology can be improved and developed. At a certain inflection point, however, the manufacturers know enough about the new technology to be able to improve its performance dramatically in a relatively short period of time and this rapid improvement results in the graph line climbing steeply. But eventually, at a second inflection point, the technology becomes mature and manufacturers are no longer able to produce dramatic and rapid performance improvements by introducing further refinements to the technology. So the graph line flattens out again.

The respective development histories of turbojet and turbofan engines provide good examples of technology S-curves, according to Tweedie. After they were first introduced in the 1940s, turbojet engines initially offered only minor performance improvements, until a period of rapid improvement became possible in the 1950s and 1960s as a result of engine

aerodynamics being refined and new materials becoming available. However, by the end of the 1960s, major further improvements to the single-airstream turbojet engine architecture became impossible as the technology approached its theoretical efficiency limit.

At that point, the introduction of the mixed-flow turbofan engine—which produces two airstreams, core air and bypass air, rather than one—offered a major new avenue for technological and performance development for another four decades. As far as the US Air Force is concerned, the superb F135 engine represents nearly the apex point of turbofan technology. However, because it is by now very mature, turbofan technology is today pushing against its empirical limits, according to Tweedie—and it may not be capable of major further performance improvements.

In its place, variable-cycle engine technology, which employs at least three airstreams to enhance performance and efficiency throughout the flight envelope, represents the future for military high-performance engines, the US Air Force believes. “This is the foundation of a whole new family [of engines] that will mature over the coming decades,” until eventually it too matures to the point where further rapid performance improvement becomes extremely difficult, said Tweedie. “That thinking is what has driven a lot of this [variable-cycle engine R&D] and a lot of the [US] Air Force’s investment in this technology.” **AI**



GE Aviation's XA100 engine under test, as developed under the US Air Force's Adaptive Engine Transition Program.

In the first part of a two-part story, AIR International covers the mighty Tornado GR4 strike aircraft after more than 35 years' service with the Royal Air Force

Tornado

Tri-national company Panavia was constituted on March 26, 1969, to manage the design and development of the Tornado aircraft for the air forces of Great Britain, Germany and Italy. That jet came to be known as Tornado. Britain had a major part in the programme and of the ten Tornado prototypes, four were built at Warton Lancashire for the UK's part of the test programme. The first of what would become the Tornado GR series of aircraft was prototype P02, XX946. The second Tornado to fly, after the German prototype D-9591, it took to the skies for the first time on October 30, 1974, at the hands of pilot Paul Millet and back-seater Pietro Trevisan. The jet was used by the manufacturer, wearing a distinctive red and white colour scheme, until it was retired in 1986. It is now part of the RAF Museum collection. The first British-built Tornado to be fitted with controls in both front and back seats, P03, XX947, first flew on August 5, 1975, with David Eagles and Tim Ferguson at the controls. At the end of its flying life it was relegated to training duties at RAF Cosford with maintenance serial number 8797M. Next off the Warton production line was P06 XX948, which again had David Eagles at the

controls when it took off for the first time on December 19, 1975. It spent most of its career on weapons trials and was the first Tornado to be fitted with the Mauser 27mm cannon. Upon retirement it too was sent to RAF Cosford as a ground instructional airframe as 8879M and is now on display at a museum in Germany. Last of the four British prototypes and the second dual-control machine, P08, XX950 made its first flight on July 17, 1976, with Paul Millet and Roy Woolett on board. It was lost on June 12, 1979, when it crashed in the Irish Sea during weapons trials. Pilot Russ Pengelly and navigator Squadron Leader John Gray, the Boscombe Down project navigator for Tornado and the second RAF navigator to fly in the aircraft, were both killed.

Pre-production Tornado PS12 XZ630 made its first flight on March 14, 1977 and was delivered to the Aeroplane and Armament Experimental Establishment (A&AEE) at Boscombe Down, Wiltshire on February 3, 1978. It never entered service with the Royal Air Force and was used as a trials aircraft. After retirement it was allotted maintenance number 8976M for ground instructional duties. Last of the pre-production aircraft, PS15 XZ631 made its maiden flight on November 24, 1978, in the hands of Jerry Lee

and Jim Evans. During a test career extending to 2004, it was involved in a multitude of tasks and was used as the prototype of the GR4 mid-life update programme that resulted in 142 Tornado GR1s upgraded to GR4 standard between 1997 and 2003. It is preserved at the Yorkshire Air Museum near York.

The first production Tornado Interdictor/Strike (IDS) aircraft was accepted by the Royal Air Force, when it was known as a Tornado GR1, on June 5, 1979, and the aircraft achieved initial operating clearance early the following year. To replace the capability lost when the Buccaneer was retired from operations, 26 GR1s were modified to what became known as GR1B standard. These jets were capable of delivering the Sea Eagle anti-ship missile.

Another interim standard, the GR1A was a reconnaissance version fitted with the Tornado Infra-Red Reconnaissance System (TIRRS), which was mounted in the space created by removing the Mauser 27mm cannon. The Royal Air Force ordered 30 GR1As, 16 custom-built jets, ZD996, ZE116, ZG705 to ZG714, ZG725 to ZG727 and ZG729. The other 14 were rebuilds of existing GR1s. Some 25 GR1As were designated GR4A after receiving the GR4 mid-life update, but the designation was dropped as the GR4s sensor



The original Tornado GR squadron, IX(B) has an illustrious history which goes back to December 1914 when it was formed at St Omer, France with BE 2s. During World War Two, IX(B) Squadron Lancaster bombers sunk the German battleship, the Tirpitz in Tromsø Fjord, Norway. During the squadron's Tornado years, IX(B) participated in many combat operations throughout southwest Asia. It is, and always will be, the best bomber squadron in the Royal Air Force. *Cpl Tim Laurence/Royal Air Force*

battle hardened at retirement

suite improved, the Reconnaissance Airborne Pod for Tornado, dubbed RAPTOR, produced by UTC Aerospace was introduced and TIRRS became redundant.

Following its operational debut in Operation Desert Shield in August 1990, the Royal Air Force Tornado GR Force (TGRF) has spent most of the last 28 and a half years on operational front-line duty defending the interests of the United Kingdom and its international coalition partners. On April 1, 2018, the Royal Air Force celebrated its centenary, which means the TGRF was on active operational duty for about 29% of the Royal Air Force's entire existence. This amazing statistic is more remarkable when one considers the hostile environments the aircraft and its personnel have operated in. The Panavia Tornado may not be in the public's top five list of the greatest ever United Kingdom military aircraft, but during the modern era, it has few peers.

As the Royal Air Force concluded its final deployed Tornado GR4 operations from Royal Air Force Akrotiri, Cyprus and both aircraft and personnel returned to their spiritual home at Royal Air Force Marham, Norfolk, we can now reflect on one of the world's truly great combat jets.

Development

In service from 1982 to 2019, the Tornado GR Force successfully evolved and kept pace with developments on the battlefield. Conceived in the late 1960s, the Tornado IDS configured to GR4 standard at the type's retirement was a very different machine to the original Tornado GR1 variant which entered service with the Tri-national Tornado Training Establishment (TTTE) at RAF Cottesmore, Rutland on July 1, 1980.

Between 1997 and 2003, Tornado received extensive modifications, which enabled it to perform the low and medium level operations the aircraft became renowned for. These included a forward looking infrared sensor, a wide-angle head-up display, night vision goggles, new avionics and a global positioning system receiver. Importantly, this upgrade programme enabled new precision-guided weapons to be integrated which included MBDA's Storm Shadow conventionally armed stand-off missiles, the Brimstone air-to-ground missile and Raytheon's Paveway III laser-guided bomb. One quite incredible system also added to the Tornado's mission systems suite was the large RAPTOR pod used to capture high-resolution imagery from stand-off ranges while flying at high speed by day or night. RAPTOR made its combat debut during Operation Telic

in March 2003 when a salvo of missiles were launched against targets in Iraq.

Additional upgrades took place from 2007 in two phases under the awkwardly named Capability Upgrade Strategy Pilot contract. Phase One enabled the integration of Raytheon's Paveway IV precision-guided munition with Phase Two adding a tactical datalink.

By now, Tornado could conduct pretty much all air-to-ground tasks the RAF required of it, and its aircrew were constantly engaged in operations as a consequence. Tornado was equally at home at low-level providing CAS (close air support) under the control of a Joint Terminal Attack Controller, operating at medium heights providing reconnaissance using RAPTOR, or engaging targets at medium stand-off ranges with Brimstone or less frequently and at much longer stand-off ranges, with Storm Shadow missiles.

These weapons enabled Tornado to conduct precision strikes against stationary or moving targets with Brimstone and against strategic, hardened targets with Storm Shadow. Tornado's precision strike capability was enhanced further with the introduction of the dual-mode seeker Brimstone from 2008 and Paveway IV from 2009 (the weapon had previously been introduced with the Harrier Force).



Discussing the aircraft's kinetic and reconnaissance capabilities prior to the final operational mission, RAF Marham's Station Commander Group Captain Ian Townsend, himself a former Harrier GR7 and Typhoon pilot and the last person to train on the Tornado GR4, said: "The high-end capabilities of the Tornado GR4 are being used day and night. As we speak [January 25, 2019], we have aircraft airborne over Syria supporting Operation Shader. Tornado continues to contribute to the Joint Task Force on a daily basis. It's very rare for one of the Tornado sorties to miss a heartbeat on operations in terms of getting airborne and completing the mission. When tasked to do something there is 100% success rate whether using Paveway IV, dual mode Brimstone or multi-seeker Brimstone 2. Despite our lower aircraft numbers, the serviceability of Tornado is superb. During parts of 2018, every single front-line Tornado was serviceable, which is testament to all those military and civilian personnel who have worked on the aircraft during the past 30 years. Component by component, Tornado is more serviceable now than it has ever been."

Combat prowess

The combat pedigree of the Tornado is unparalleled in Royal Air Force service, not just during the noughties, but back another decade too. With the power generated by two Rolls-Royce RB199 Mk103 turbofan engines each rated at 16,400lb (71.2kN) of wet thrust the aircraft had the flexibility to engage strategic

hardened targets, those dubbed targets of opportunity, moving targets and those simply requiring to be blown up in an orderly manner. Whatever the combatant commander's required, Tornado was the UK's go-to platform with which to destroy an enemy.

The Tornado GR1 made its debut combat deployment in August 1990 under Operation Granby, the UK's contribution to the US-led Operation Desert Shield and subsequent Operation Desert Storm, for which the Royal Air Force based approximately 60 aircraft at bases in Bahrain and Saudi Arabia. Six aircraft were lost during the conflict. Blackburn Buccaneer aircraft equipped with the Paveway IV precision-guided munition were also based in the Gulf during Operations Desert Shield and Desert Storm to spike targets for Tornados to drop precision-guided munitions. GEC Marconi's Thermal Imaging Airborne Laser Designator targeting system was introduced into service in 1990 to further enhance the platform's capabilities.

Following the UK Tornado GR1 mid-life upgrade which started in 1993, the newly configured Tornado GR4 made its operational debut patrolling the skies above Iraq during Operation Southern Watch. In 1998, Tornado GR1s and GR4s operating from Kuwait participated in the US-led Operation Desert Fox, a series of coalition air strikes against Iraqi military infrastructure.

One year later, Tornado GR1s, operating initially from RAF Brüggen, Germany, participated in the Kosovo War as part of the US-led Operation Allied Force. Over the

subsequent few years, Tornado GR1s were either upgraded to GR4 standard or phased out as the mid-life upgrade was completed.

Iraqi President, Saddam Hussein was once again the cause of the RAF Tornado GR Force to be called to arms under Operation Telic, the UK's contribution to the US-led Operation Iraqi Freedom and the invasion of Iraq. Complex and highly demanding in nature, Operation Telic enveloped the Tornado GR Force for six years.

Soon after the Operation Telic commitment finished in May 2009, Tornado GR4s were deployed to Afghanistan on Operation Herrick, replacing the Harrier GR7s and Harrier GR9s in the process. During the next five years, the Tornado GR Force completed over 5,000 sorties against the Taliban, using the Paveway IV precision-guided munition to good effect; the first time Tornado had released the munition in anger. Its time in Afghanistan included an uncertain period for the Tornado GR Force, which prior to the UK government's 2010 Strategic Defence and Security Review was in line for retirement.

By March 2011, Tornado GR4s were again in action, this time helping enforce a no-fly zone over Libya alongside RAF Typhoons during Operation Ellamy. In March, Tornado GR4s conducted long-range, round-robin strike missions deep into Libya flying directly from and to RAF Marham refuelling several times in the air. In terms of duration, the series of missions were the longest conducted by the RAF since the famous Vulcan Black Buck raids on the Falklands during the 1982 war.



A Tornado GR4 on patrol over Iraq in 2007 during Operation Telic.
14 Squadron/Royal Air Force

TGRF's final combat tour commenced in August 2014 following a UK government's decision to deploy GR4s to RAF Akrotiri, Cyprus for Operation Shader. Initially the aircraft were used for their surveillance capability with the RAPTOR pod, notably to help protect Yazidi people sheltering from Islamic State in the Mount Shinjar region of northwest Iraq. Just a few months later, the deployed force at RAF Akrotiri (which from late 2015 included Typhoon FGR4s) was approved to conduct strikes against Islamic State fighters operating inside Iraq and Syria. Extensive details on the Tornado GR4's combat operations over Syria and Iraq will appear in AIR International's May 2019 issue.

The scale of combat effort undertaken by the Tornado GR Force during its service life is reflected in the operational service hours accumulated. During an operational sortie over Afghanistan on June 27, 2011, a Tornado GR4 flown by a 617 Squadron crew took the RAF fleet through the one million flight hour mark.

Given the TGRF's declining fleet size, and an estimated annual 22,500 flight hours, AIR International estimates the fleet had chalked-up in excess of 1.15 million flight hours when the final aircraft retired from service in March.

Air Marshal Stuart Atha, Deputy Commander Operations Royal Air Force, reaffirmed the remarkable operational contribution made by the Tornado GR Force as the final jets returned to RAF Marham on February 6, 2019. He noted that an aircraft designed in the Cold War had been used in a succession of hot wars and for the last four and a half years, had

been operational in the most challenging of combat environments. Astonishingly, apart from a brief eighteen-day period in 2009, since August 1990 the Tornado GR Force was continuously deployed on operations in Southwest Asia (Afghanistan, Iraq and Syria).

Gp Capt Townsend also paid tribute to those who had played a part in sustaining the enduring capability of the Tornado GR Force. He said: "Having conducted nine major operations since 1990, today [February 6] sees the return of the Tornado GR Force from its last operational commitment, Operation Shader. Having flown almost 30,000 flying hours and 3,300 missions over Iraq and Syria over the previous four-and-a-half years, the force is returning to the UK ahead of the Tornado's retirement at the end of March 2019. Having served on operations continuously for almost 28 years, the Tornado GR Force has made an exceptional contribution."

Original Tornado vs modern Tornado

So how did the modern Tornado compare to the original jet? Discussing this interesting aspect of the jet, Gp Capt Townsend reflected on how combat air power has transformed during his 28-year Royal Air Force career. He said: "Back then the Air Force was much bigger, and used single aircraft types to conduct each role. Today's Air Force has two types of strike fighter, Typhoon and F-35, integrated and operating together. Speaking at RAF Marham on January 10, the Secretary of State for Defence announced that Project

Centurion, a major capability improvement programme for the Typhoon, had been released to service. But the advancement of capability provided by Centurion is not just about kinetics. What Typhoon and F-35 introduce is an advanced and different avionics capability; not just their radar capabilities, but also electronic warfare and electronic attack. Much more sophisticated than the blunt instruments of the Cold War.

"The Tornado was designed to operate at low-level for airfield attack fitted with the JP 233 [airfield denial system, one that delivered multiple sub-munitions]. Tornado GR4s in service at the end of Operation Shader are incomparable to those in service when the Air Force first started to conduct combat ops back in the early 1990s."

Respect

Flight Lieutenant Nathan Shawyer of 31 Squadron was the last ab-initio pilot to transition to the Tornado GR4 in February 2017. After returning to RAF Marham in one of the final three Tornado GR4s deployed to Cyprus, he confirmed why the aircraft was so popular with aircrew: "Tornado is a fantastic aircraft to fly. It's a mechanical beast, it feels old school, which is absolutely suited to the low-level environment. This is where it thrives – the jet is rock solid at 250 feet and 450 knots – allowing a stable platform for legacy dumb bomb releases. The engines also react brilliantly in the lower, thicker air providing ample thrust to accelerate through winding valleys. The fact Tornado is crewed by two

aircrew cannot be overstated. This allows a massive degree of flexibility, particularly during operational missions where things can get very busy very quickly. For example, the navigator [or weapons systems operator] can concentrate on receiving a complex talk on [guidance] to the target from troops on the ground using the Litening III pod – whilst the pilot can concurrently talk to the airborne command and control element, discussing options for extensions of task, air refuelling changes, all while flying in the overhead. Two heads are definitely better than one in the targeting environment. When the final engagement clearance comes, it's reassuring to be able to talk through the attack, having a second pair of eyes and ears to check each other's work prior to releasing the weapon.

"I'd say the love for Tornado is built out of a reliable success story. It delivered time and time again over years of service. The airframe is ageing, however successive avionic and weapon upgrades allowed the Tornado to remain on the cutting edge of technology for air-to-surface attack. The aircraft evolved admirably, from a Cold War nuclear-strike bomber to a modern close air support platform, delivering precision-guided munitions from great range. This was never more evident than in the last year's strikes against President Assad's chemical weapons facilities [in Syria], where four GR4s formed coalition forces releasing eight Storm Shadow missiles under the cover of darkness [April 14, 2018]."

Welcome home

The first five jets to return to RAF Marham from Operation Shader landed just after 14:00hrs local time on Monday February 4, 2019. In order of landing they were ZA597/063 using callsign 'Ascot 9523', ZA463/028 'Ascot 9521', ZG791/137 'Ascot 9522A' ZD848/109 'Ascot 9524', and ZA542/035 'Ascot 9522B'.

By 10:15hrs Zulu on Tuesday February 5, 2019 Royal Air Force Voyager KC3 ZZ336 using callsign 'Ascot 9103' was passing over Crete with three Tornados in tow. The tanker turned around and went back to RAF Akrotiri when the formation was just short of the French coast.

Enthusiasts on the fence at Marham were speculating that two Tornados would return to the UK and one would stay at Akrotiri to serve as a reminder of the Tornado's long association with the base over the previous decades. In the event, all three aircraft, ZA601/066 'Ascot

9526', ZD744/092 'Ascot 9527' and ZA587/055 'Ascot 9528' made the journey from sunny Cyprus to a cold, cloudy Marham.

As if to emphasise that aviation is an inherently dangerous pursuit, Tornado GR4 ZA601, which was being flown by Wing Commander Heeps (OC IX Squadron) and Wing Commander Bressani (OC 31 Squadron), had been slated to be the first to land. However, reported problems with the left-hand hydraulic system about the time it entered UK airspace, meant crew elected to allow the rest of the formation to land first.

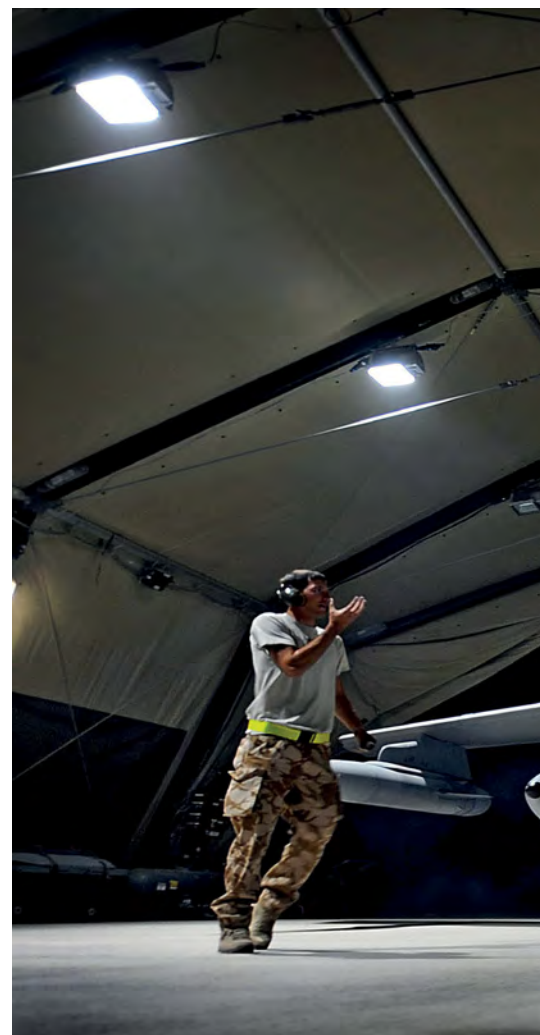
After a few minutes, at 14:09hrs local time the pilot broadcast a PAN message (one down from MAYDAY in order of urgency) and commenced dumping fuel north of RAF Marham. After a tense few minutes the jet recovered safely. The other two landed in turn and their crews taxied in to face their next ordeal – the press!

Wg Cdr Heeps provided his thoughts on landing at Marham: "It is mixed emotions in a way as this aeroplane is first and foremost a combat aircraft. Tornado has done that for the last time which is sad as we have all dedicated our careers to it. There is also huge pride in what the aeroplane has done, the people who have flown and maintained it. It is a privilege to be here and part of that. There have been plenty of missions that stand out in my mind. Some flying over Libya and operating hundreds of miles inside the desert a long way from safety. Launching from Marham to do an operational mission having spent the morning shopping at home was an interesting one. The last operational mission we flew on January 31 was probably the most memorable, bringing that era of 28 operational years to an end."

Flight Lieutenant Nathan Shawyer of 31 Squadron, flew ZA587/055 home and told us: "it was an immense thing to be part of, a really awesome mission and to see all the crowds gathered both at Akrotiri this morning when we left and here at Marham. That shows much this aircraft means to so many people which makes me feel immensely proud to be part of its history. It is incredible to think this aircraft has been on operational missions for longer than I have been alive, and in the Air Force for a lot longer than that. To be part of that is just great."

Telic: Tornado over Iraq Somewhere over Baghdad – 1014hrs local time

"Bravo Charlie 23, this is Bluetooth" – "Bluetooth, Bravo Charlie 23 go ahead" the



pilot of a GR4 over Sadr City, Baghdad, replies – "Bravo Charlie 23 you've been re-tasked to support a TIC [troops in contact] in 78AS Keypad 3; contact Echo Foxtrot 14 on Purple 9 for tasking, good hunting"

That's the first a Tornado GR4 crew would normally know that things were about to get interesting during a typical CAS mission over Iraq. Even for those with previous operational experience, the hairs went up on the back of their necks, and they knew that in the next few minutes they could be asked to deliver in one of the most demanding and rapidly-changing scenarios that they were likely to encounter during their flying career.

In the time it has taken you to read to this point, the pilot had already manoeuvred his GR4 inbound the tasked area, and with the afterburners in, "We'll be overhead in less than a minute" the navigator relayed to the Joint Terminal Air Controller [JTAC] that the crew had been tasked to support.

From the squadron commander's perspective, this was the culmination of many months of training for one of his crews. The work up had effectively begun just a couple of months after the squadron's last Operation Telic deployment, during an exercise staged in the United States called Torpedo Focus held at Hill Air Force Base, Utah. During Torpedo Focus, the squadron dropped Enhanced Paveway II GPS-guided munitions, laser-guided bombs and fired live ammunition from the 27mm Mauser cannon, all under the control of US JTACs and UK

Stradders

Many people have flown many thousands of hours in Tornados but probably none has flown more than one of the crew members of one of the Tornados that returned to Marham on February 6.

Weapon system operator, Flight Lieutenant Chris 'Stradders' Stradling logged his 6,000th flight hour in a Tornado on the trip back from Cyprus. The veteran instructor had reached another milestone in 2016 when the combined total of Tornado flight hours of himself and his pilot, Squadron Leader David Gallie, both instructors with XV (R) Squadron exceeded the astonishing total of 10,000!

At the time of the milestone flight Gallie had amassed 4,800 hours on the Tornado and 7,500 total career flying hours, while Stradling had a total of 5,300 Tornado flying hours and over 5,600 hours in total. Stradders had gained his badge for 5,000 flight hours in Tornado when serving as an instructor with XV (R) Squadron at RAF Lossiemouth in 2014.

Stradders will be remembered by many as one of the crews who performed Tornado role demonstrations over beaches, air shows and other events across Europe earlier in the decade.

Upon landing at Marham he was presented with his 6,000 flight hour badge – an accolade unlikely to be bestowed on anyone else in any Air Force. For an idea of what a stupendous achievement this is, 6,000 hours equates to 150 40-hour working weeks. So, if we give our intrepid airman two weeks holiday a year, that amounts to three 50-week work years spent strapped into an uncomfortable manned missile. Bravo sir, Bravo!

Kandahar airfield, Afghanistan. A 31 Squadron Tornado GR4 loaded with a Paveway IV precision-guided munition and a RAPTOR pod under preparation for a night time mission during Operation Herrick. POA(Phot)

Tam McDonald/Royal Navy



Forward Air Controllers (FACs) operating on the ground. Later in its work-up, the squadron flew on several other CAS exercises, including urban CAS over the RAF base at Akrotiri, Cyprus a reasonable simulation of the type of environment they would later encountered over Iraq.

Just six weeks earlier, the crew of Bravo Charlie 23 had participated in Exercise Red Flag and flown highly realistic CAS missions over Gotham City in the Nevada desert. And so, the squadron crews were trained and ready for what they were about to be exposed to. But no one could predict exactly what the day's mission would bring in a fast changing urban environment. An intelligent approach is required, testing the crews' knowledge of rules of engagement, the law of armed conflict and their ability to interpret the priorities of the ground commander.

Commitment to close air support

During Operation Telic and Operation Herrick, the Royal Air Force was heavily committed to CAS operations in Iraq and Afghanistan. In spite of the frustration of occasional misinformed press coverage, the Harrier Force in Afghanistan developed an enviable reputation with the troops it supported on the ground.

In Iraq, the Tornado GR Force was asked to increase its contribution to Operation Telic by 25%. Equipped with the latest Litening III RD targeting pod, the Tornado GR4 continued to be revered as the platform of choice by many of the JTACs and TACPs on the ground.

The significant efforts made by UK armed forces in improving air-land Integration based on lessons from the Kosovo campaign and the second Gulf War, further enabled by the introduction of technologies such as those of the Litening RD, transformed RAF fast jet frontline fleets into key assets in coalition operations over Iraq and Afghanistan. As a result, the proportion of CAS training conducted significantly increased over the years, in particular for the Tornado GR Force. However, as high profile cases such as 12(B) Squadron's prevention of the capture of an Iraqi Police General by insurgents proved, the extra training was worth it. More to the point, comments from troops on the ground such as, "Hey, those gunners in the Humvees sure do appreciate you extending your sortie to cover them back to their base," or "the ground commander at the scene of the incident says thanks; you saved lives today", gave reassurance that all the training was worthwhile.

Northeast Baghdad – 1020hrs local time

The crew of Bravo Charlie 23 had been on scene for several minutes. The weapon system operator (WSO) had passed his fighter to FAC check to declare his weapon load-out to the JTAC who had passed back the coordinates of the TIC. Now loaded into the aircraft's main computer, the WSO slaved the Litening III to the target area and linked his video to the JTAC on the ground, the JTAC then talked him

onto the exact area of interest, highlighting where the friendlies were and built up the crews' situational awareness of the incident.

Tense scene

The scene on the ground was tense. Insurgents were holed up in a building on the edge of a village and the Iraqi Army patrol that had been carrying out a sweep of the area was taking incoming fire from small arms. Initially the JTAC called the GR4 in for a show of force; a low pass at high speed – a task that RAF crews are still the best trained in the world to conduct. Of note, as tactics have changed, the RAF is one of the few air forces that continues to train crews in operational low flying, as low as 100ft above the ground. Anyone who has experienced a jet at that height will know; the impact is impressive. If a situation can be suppressed with the threat of air power, then that is a good thing for everybody. Unfortunately, on this occasion the show of force did not have the desired effect and the insurgents escalated the threat by firing an RPG (rocket propelled grenade) at an escorting US Stryker Wheeled Armoured Vehicle. The RPG missed, but there was an imminent threat to coalition forces that had to be neutralised. The JTAC marked the friendlies position and the GR4 crew had a good visual on them. The GR4 crew was called in to strafe the building, the 27mm Mauser cannon proved the ideal low collateral weapon to employ given the proximity of other buildings.



Northeast Baghdad – 1025hrs local time

"Echo Foxtrot 14, Bravo Charlie 23 is 30 seconds" called the GR4 pilot "Bravo Charlie 23, you're cleared hot" replied Echo Foxtrot 14, the JTAC, and shortly thereafter, 35 rounds of carefully aimed 27mm high explosive ammunition hit the target building. "Good Hits", calls the JTAC. Following the strike, no further fire was reported. The Iraqi Army patrol entered the building and several insurgents, some wounded, were detained; the GR4 remained on station as the ground parties exited from the village. Forty-five minutes later, the Tornado GR4 was tanking from a US Air Force KC-135R, prior to going back on patrol over Baqubah, working with another JTAC.

The day's mission lasted eight hours for the GR4 crew, a long time to sit in one place, but a job that was always considered to be well worth the uncomfortable, cramped conditions. Such a scenario was commonplace for GR4 crews flying over Iraq on Operation Telic back in 2007.

Herrick: Tornado in Afghanistan

Royal Air Force Tornado GR4s operating from Kandahar Airfield, Afghanistan provided formidable air support to coalition forces since they arrived there in June 2009; each Tornado GR4 squadron spent three months in theatre. Between April and July 2010 that duty fell to II (Army Co-operation) Squadron based at RAF Marham, Norfolk.

The squadron's primary role was to support coalition forces on the ground by providing CAS and to conduct reconnaissance. CAS involved flying pre-planned missions, often remaining overhead coalition forces to deter enemy forces from attacking, a tactic called armed over-watch. In the reconnaissance role a Tornado GR4 fitted with a RAPTOR pod, provided detailed stereo imagery of the ground. The high quality of images captured by RAPTOR allowed troops to walk the ground and see what it looked like before they did it for real. RAPTOR imagery also helped identify possible improvised explosive devices.

Ground alert

Another element of CAS was ground close air support or GCAS, which involved aircraft being held at a high state of readiness for responding to a call, to quickly get airborne and to the required location where troops were being engaged by the enemy, colloquially known as a TIC.

Ground crew were allowed to prepare the aircraft prior to the aircrew arriving; a procedure used to save time and allow the aircrew to get airborne quickly.

During the last four months of 2009, GCAS was launched 14 times, equating to 28 aircraft and sorties. While II(AC) Squadron was deployed to Kandahar between April and July 2010 the average weekly total of GCAS launches increased to four launches per week; a situation caused by a greater number of coalition troops operating in Afghanistan and thus a greater likelihood of enemy contacts.

Following a call, the crews were required to be airborne within 30 minutes, but often did so much quicker; the quickest achieved by II(AC) during its 2010 tour was within three minutes, though the aircraft were being prepared at the time and ready to go.

On reaching the area of conflict, contact was made with the Joint Terminal Attack Controller, a troop trained to guide aircraft into the area and have a good understanding of the capabilities that the Tornado GR4 could deliver for them. The JTAC described the situation on the ground and with input from the aircrew decided how best to respond. A kinetic response was only used in life and death situations.

The GCAS alert during II(AC) Squadron's 2010 deployment at Kandahar was shared with Belgian Air Force F-16s, each providing 12 hours of cover. Two primary aircraft and crews were allocated, plus a spare aircraft. The 12-hour duty period was split into two shifts of five and seven hours respectively. Typical munitions payload for a GCAS mission was two 500lb Paveway IV precision-guided munitions, a dual mode Brimstone missile, 27mm high explosive rounds, a Litening III targeting pod, two 1,500-litre external drop tanks and two outboard flare dispensers; one Boz and one Advanced Infra-Red Countermeasure pod.

GCAS requests were made by the Air Support and Operations Centre located at the NATO International Security Assistance Force Headquarters in Kabul via a system called the Microsoft Internet Chat Room (mlCR). The

To mark the Tornado GR's retirement from RAF service, paint crews at RAF Marham painted aircraft ZG752 in the colour scheme originally applied to all Tonkas when the type entered service in 1980. The aircraft's spine features a crest of each and every RAF unit that operated the Tornado GR. *Ian Harding*



computer-based communication system detailed the location, callsign and type of engagement. Once the squadron's watch-keeper read the alert message, and received the follow-up phone call, he or she sounded the horn to notify the aircrews, while the groundcrew were summoned by the GCAS bell.

The RAF's preferred method of dealing with a situation was to perform show-of-force, a very low and fast pass overhead the enemy, which often provided enough to deter the enemy. If the show-of-force proved ineffective, the aircrew would respond in an escalatory manner first using the 27mm cannon, which causes the least damage, then if necessary escalate to a Brimstone missile, and finally a Paveway IV.

During such an engagement, the Litening III targeting pod provided a high resolution picture in the cockpit of what was happening on the ground. The picture could also be transmitted to a receiver held by the JTAC and used to help the aircrew positively identify the enemy before any action was taken.

Turus: Tornado in West Africa

When three Tornado GR4s departed RAF Marham early one morning in late August 2014, the crews from II(AC) Squadron were making history. The sortie was the longest RAPTOR mission ever flown from the UK. It was also notable because the targets were located in the West African nation of Nigeria.

The order to deploy was received a couple of days before. The only prior knowledge of a

possible tasking came earlier in the year when the squadron sent a small team to its eventual location, the Armée de l'Air's BA172 N'Djamena in Chad. The site-recce checked the safety issues of operating fast jets in a region the RAF had not previously deployed to.

The Tornados flew for just under eight hours in a single-leg trail to West Africa supported by Voyager tankers. More significantly the Tornado aircrews conducted the first operational sortie at the end of the trail before recovering to BA172 N'Djamena for the first time. The objective of the deployment was to find a group of Nigerian school girls kidnapped by Islamist extremists Boko Haram. Two of the aircraft carried a RAPTOR pod for gathering high-quality stills, the other was fitted with a Litening III to capture real-time imagery and video if required.

On landing, all of the imagery captured was quickly turned around by a team from the Tactical Intelligence Imagery Wing (TIW), also based at Marham, and sent to UK commanders.

The deployment was built around a 'shaved-down' Expeditionary Air Wing, limited in numbers because of accommodation and space for the aircraft at the airfield.

The team comprised of hand-picked personnel, each with multiple skills to ensure the operation's required output – intelligence products – was achievable. There was a heavy reliance on host nation support and the Armée de l'Air which maintains a significant presence at the base. The first sortie was launched two days after arrival.

The RAF was shy in saying how many pods were deployed but stressed the number gave the EAW sufficient redundancy. It also confirmed no missions were cancelled due to the lack of a RAPTOR pod.

Pods had to be changed on a couple of occasions because of humidity and the temperature rise encountered at the base. Crews planned each mission in the early morning to give the best conditions for taking pictures and the best chance of success with the pods when faced with the cooling requirements in the hot and humid environment.

Unlike Afghanistan, West Africa is a green and humid place, particularly in the monsoon season, which meant aircrew had to capture imagery at the right time of day to avoid cloud and rain where possible.

Atrocious weather on the day of the first planned sortie caused it to be cancelled. The region had thunderstorms extending up to 50,000ft (15,240m), icing conditions, massive down drafts and very quick changes in conditions. The following day brought bright blue skies and a mission that went ahead.

Crews had to be ready to re-plan while airborne; a challenging prospect with RAPTOR that involved plenty of communication and crew resource management between the two cockpits, ensuring the best imagery was captured through cloud gaps. This might have involved holding the altitude, changing the stand-off range and the type of image taken to ensure the tasking requirement was met.

Mission aspects

West Africa is a big region and the Tornado crews were searching for targets in an area covering hundreds of thousands of square miles. Part of the tasking involved specific points of interest given through the tasking chain. The other part involved collecting imagery of larger swathes of land to increase knowledge of the region.

A typical sortie lasted between 90 and 120 minutes during which the amount of data gathered by the RAPTOR pod, in terms of volume, was the equivalent to a mission in Afghanistan lasting two or three times longer. One Tornado pilot described the sorties as very busy in terms of data collect which was maximised by having RAPTOR alongside Litening, or two aircraft each equipped with a RAPTOR pod when required. The stores configurations of the two aircraft enabled both video and still images to be recorded.

Operating in a part of the world that lacked full-radar cover meant that a lot of the flying was to VFR (visual flight rules), and knowing where to fly and which other airfields to speak with all to increase the level of situational awareness of the crew. Part of the planning process was to assess the flight safety and operate as reasonably as practical in the threat and risk environment of the region.

Operation Turus was effectively a search mission, therefore all imagery captured during the sorties had to be sifted through for positive leads. The TIW team was faced with a huge amount of imagery to process and analyse. To handle the workload, the number of image analysts deployed was increased

during the initial phase. This allowed the team to operate around the clock and maximise the number of intelligence-based reports produced. Each report contained just the key parts from all of the imagery acquired, and sent to the command for further analysis.

RAPTOR pods used on Operation Turus were configured with the latest iteration of software and supported by the then current version of ground support stations.

During the two-month deployment the detachment flew 55 sorties and dropped just one.

What now after RAPTOR?

AIR International asked Gp Capt Townsend how the Air Force was plugging the gap in reconnaissance capability left by the loss of the Tornado-specific RAPTOR pod. He said: "Tactical reconnaissance is something the Air Force has done for many years and has been seen as a lead in the role so the loss of RAPTOR takes something unique out of the inventory. RAPTOR has been seen as a very useful capability, particularly by our American allies. The future for tactical reconnaissance, certainly on Typhoon, lies within further advancements in targeting pod capability. There are significant advances with the Litening pod, but that said, it is not a comparison of apples with apples [RAPTOR with Litening III]."

So what next for reconnaissance? Gp Capt Townsend explained that the shiny new F-35B Lightning will conduct the role in a slightly different way to legacy types like the Tornado GR4. He said: "The F-35's sensor fusion

capability provides a much more thorough, and different, intelligence picture compared to pure high-resolution imagery as gathered by the RAPTOR pod.

Today's and tomorrow's battle spaces will have so much happening within them; much more than can be captured with cameras and the eyes of image analysts."

Remember the F-35 is equipped with a multimode AESA radar, an integrated electro-optical targeting system, an advanced electronic warfare system and a distributed aperture system; a suite of sensors which are all fed to what's known as a fusion engine, one of many very advanced systems built into the heart of Lockheed Martin's stealth fighter. The fusion engine provides the pilot with a fused overview of the battle space, all served up on a large and very groovy cockpit display.

What now for the TIW?

Given the retirement from service of the RAPTOR pod, AIR International asked Gp Capt Townsend what the future held for the once Marham-based Tactical Imagery Wing (TIW) and its highly-skilled cadre of personnel and image analysts. He said: "The Tactical Imagery Wing is already in the process of transferring to Waddington, the RAF's ISR hub. Its personnel will coalesce around Waddington, and its role will change subtly from photographic interpretation to interpretation of ever more intelligence data from across the electromagnetic spectrum. The Air Force continues to collect intelligence, but is doing so in subtly different ways; ones which are entirely appropriate for the battle space of the future.



"The Tactical Imagery Wing has been absorbed by 1 ISR Wing which stood-up at Waddington in 2016. One of the two flights in the TIW has remained at Marham [to provide analysis and dissemination of intelligence data acquired from RAPTOR imagery] but will move to Waddington over the next six months and the transition has already started."

Tornado: the greatest?

When AIR International asked Gp Capt Townsend whether the Tornado GR4 can be considered the greatest aircraft since the days of Hurricanes, Spitfires and Lancasters, the station commander paused, and then responded. "That's a very interesting question. During presentations I often pick someone in the audience to give me their top five iconic RAF aircraft. Tornado doesn't regularly feature in a top five. Yet in August 1990, Tornado GR1s first deployed to the Middle East and only returned to the UK for a short period in 2009. The type has effectively been on ops since 1990: more than a quarter of the RAF's 100-year history. That's incredible. What's also nice is the fact that the Tornado started and finished its operational service at RAF Marham."

As mentioned earlier, Gp Capt Townsend's RAF flying career began with the Harrier, through Typhoon and finally the Tornado GR4, but he won't fly the F-35B. He holds perhaps an expected view on that: "Wow am I envious, you have to be envious. The F-35 Lightning is without doubt the best combat aircraft on the planet, and we are only just scratching the service in

discovering how good the aeroplane will be. With the F-35 operating alongside Typhoon as sovereign capabilities, the future of UK combat air power is very bright."

Tornado retirement

In preparation for Tornado's official withdrawal from service on March 31, 2019, RAF Marham hosted a number of events to celebrate its service career. The first of these took place on January 25 when three specially-painted Tornado GR4s were presented to the public for the first time. Two carried unique tail markings, aircraft ZG775/AF representing IX(Bomber) Squadron and aircraft ZD716/DH representing 31 Squadron; the last two units to fly the type. The third jet, ZG752 was painted in a retro camouflage scheme, as worn by the Royal Air Force's original Tornado GR1s. This aircraft displayed squadron badges commemorating each squadron that flew the Tornado IDS along its fuselage spine. Two days earlier, all three specially marked jets participated in an air-to-air photo shoot before performing a series of flypasts on their return to RAF Marham. Before the end of March, further formal events were held to commemorate its historic service. These included a media event on February 6 to mark the return of the Tornado GR4s deployed to RAF Akrotiri following their participation in Operation Shader, the United Kingdom's military intervention against the Islamic State of Iraq. Formation flypasts were also performed throughout the United Kingdom by three Tornados over multiple sites associated with the Tornado's history between February

19 and 21, dubbed the farewell tour. Flying events culminated with a final eleven-aircraft launch and diamond nine flypasts at Royal Air Force College Cranwell and RAF Marham on February 28.

Having participated in these formations, Flight Lieutenant Shawyer expressed his pride at having the opportunity to pilot the iconic jet during the missions: "Flying in formation with the three specially painted jets was a great moment for me, and to be able to fly one of the aircraft with my name on the side was quite an honour."

At the time of the Shader jets' return, 16 Tornado GR4s remained in the active fleet but that number soon dwindled with some of the returning veterans destined never to fly again. After the February 29 nine-ship, the only time a Royal Air Force Tornado GR4 took to the air was on a last flight to a final resting place for preservation. The others will be dismantled at Marham and spares may find a buyer on the international, principally Germany.

Both squadrons operating the type at the end of Royal Air Force service have slightly different futures. After 31 Squadron 'Goldstars' disbands in March, the unit will reform, probably in 2024, at RAF Waddington, Lincolnshire equipped with the General Atomics MQ-9B unmanned aerial vehicle dubbed in RAF service as the Protector RG1. Lastly, IX(B) Squadron 'Bats' will reform with the Typhoon FGR4 at RAF Lossiemouth, Moray with a stand-up parade to mark the event scheduled for May 2. Both squadrons marked their status change with a disbandment parade at RAF Marham on March 14, 2019. **AI**



Tornado walk. Twelve Tornado GR4s taxi down runway 19 at RAF Marham on February 28 following the nine-ship flypasts at RAFC Cranwell and Marham. This was the final day of RAF Tornado operations from RAF Marham. *Ian Harding*

Tilting toward



Leonardo's nine-seat, eight-tonne AW609 tiltrotor is one of the most unusual-looking aircraft around.

Leonardo

Leonardo da Vinci (1452-1519), the famous Renaissance artist and engineer, drew and painted the future as he envisioned it, including a design of a rotorcraft: the very first helicopter.

One wonders what da Vinci would have thought of how his ideas have been imagined and developed over 500 years later – especially as AgustaWestland, itself the merger of the two famous helicopter manufacturers, Westland Helicopters and Agusta, in 2016 rebranded itself as Leonardo.

Among the range of light, medium and heavy rotorcraft products manufactured by Leonardo, the latest – and undoubtedly one of the most distinctive – is the nine-seat, eight-tonne AW609 tiltrotor fitted with two Pratt & Whitney PT6 engines.

Programme history

The AW609 started life in 1996 as a Bell-Boeing venture, following their development of the much larger V-22 tiltrotor for the US military.

Comparable in size to Bell's two-seat XV-15 experimental demonstrator, the AW609 incorporated a similar concept to the V-22: lifting and hovering like a helicopter then flying like a conventional fixed-wing aircraft.

The XV-15 flew successfully in 1977 and subsequently a second airframe was built. Unfortunately, the first one, N702NA (c/n 0001), crashed in 1992 and the second, N703NA (c/n 0002), continued to be used until its retirement in 2003 to the Steven F Udvar-Hazy Centre at the Smithsonian Museum.

Agusta joined the venture in 1998 when Boeing withdrew from the project to focus

exclusively on military rotorcraft, creating the Bell Agusta Aerospace Company (BAAC), with the head office in Arlington, Texas. BAAC was also responsible for developing the AB139 (now the AW139 after AgustaWestland took 100% of the programme and subsequent deliveries).

The XV-15 was renamed the BA609 and development started in earnest. BAAC brought their mock-up of the BA609 to Farnborough Airshow in September 1998 and to the following year's Helitech International Helicopter Exhibition at Redhill.

In 2002, the prototype, N609TR (c/n 60001), underwent several weeks of ground runs and taxiing before, on March 6, 2003, test pilots Ray Hopkins and Dwayne Williams flew the aircraft successfully for the first time from Arlington, Texas.

ds the future

Ian Frain looks at Leonardo's AW609 tiltrotor



During subsequent test phases the BA609 flew 14 hours, with the nacelles in the full aft to 15° position. The flight test team also conducted upper air work with various exercises such as pedal turns, forward and rearward flight and hovering. They also managed to fly the BA609 up to 5,000ft.

The aircraft then returned to ground testing, evaluating the different transition modes and testing various software, including the BAE Systems-supplied flight control system. Another milestone was reached in July 2005 when the BA609 transitioned from helicopter to fixed-wing mode in flight.

European tilt

The second prototype, N609AG (c/n 60002), was shipped from Arlington to AgustaWestland's facility at Verigate in

Lombardy, northern Italy. This aircraft flew in 2006 in fixed-wing mode and later appeared at the 2008 Farnborough Airshow in Hampshire, performing during the week.

By October 2008 both N609TR and N609AG had achieved 365 flight hours. In 2009, the BA609 achieved another successful test, this time demonstrating the safe dual engine failure in cruise mode. In September that year the European-based N609AG flew to Ulrichen in Switzerland to conduct tiltrotor tests.

Bell pulled out of the programme in November 2011, making AgustaWestland the sole owner. The aircraft was subsequently renamed the AW609. Both prototypes had achieved over 850 flight hours by January 2014.

A month later N609TR appeared at that year's Helicopter Association International (HAI) Heli Expo 2014 in Anaheim, California, where it performed several customer demonstration flights. Ten hours of autorotation tests were flown, which included the power-off-conversions from aircraft mode to helicopter mode.

By early 2015, AW609 flight testing with N609TR in Texas and N609AG in Europe had accumulated approximately 1,200 hours. The AW609's performance had expanded to 18,000lb (8,165kg), a speed of 293kts (543km/h) and 30,000ft altitude.

During HAI Heli-Expo 2015 in Orlando, Florida, AgustaWestland and the Bristow Group signed an agreement to further tiltrotor development. The Bristow Group is long established in the offshore helicopter industry,



Lifting and hovering like a helicopter then transitioning to forward flight like a conventional fixed-wing aircraft gives the AW609 potential in various applications. *Leonardo*

but also owns a couple of fixed-wing charter operations, the UK-based Eastern Airways and Australian-based Airnorth.

At present the two airlines fly oil rig crews to the furthest airport (Stornoway in the UK for example) where they then take the helicopter to the rig. N609TR appeared on static display at the AgustaWestland booth painted in Bristow Group colours, with the Bristow logo on the starboard side and Eastern Airways on the port side.

Tilting forward, further out

The AW609 is expected to compete well in the offshore marketplace because of what Leonardo's Head of Tilt Rotor Marketing Bill Sunick envisions, "is a great potential for the AW609 to introduce new levels of safety, performance and savings for operators".

By flying at altitudes up to 25,000ft the AW609 can safely transport its passengers in the comfort of a pressurised cabin above the bad weather that would delay or cancel conventional helicopter flights. Sunick said a company can lose both time and money if rig crews are stood down because of bad weather.

Additionally, the AW609's high speed and long range would eliminate the need for operators to employ a mixed fleet of both fixed-wing aircraft and helicopters, saving them the expense of having two different sets of flight crews, engineers, maintenance and support equipment and training curriculum.

The AW609 made its second UK appearance at the RNAS Yeovilton Air Day 2015 with N609AG performing for the crowd. On September 15 that year N609AG flew point to point from the AgustaWestland facility at Yeovil to the company's Cascina Costa facility outside Milan, 627 nautical miles (1,161km) away, in just two hours and 18 minutes. N609AG lifted off vertically from the Yeovil facility and climbed up to an altitude of 25,000ft, passing over Southampton

before crossing the Channel, past Paris and south to the Alps, then over Piedmont before descending and landing at Cascina Costa.

Tragically at the end of October 2015, the programme suffered a setback when the N609AG crashed during a test flight, killing both test pilots.

Speed is crucial

Sunick spoke of the many advantages in terms of cost and response time that emergency medical services (EMS) operators around the

world, who currently operate fixed and/or rotary-wing assets, would experience if they were to combine the two.

The AW609's high speed and long range greatly maximises the critical 'Golden Hour', those precious 60 minutes after a traumatic injury during which a patient's chances for survival greatly increases if treatment is administered.

Speed is of the essence in many medical procedures, especially in speciality surgeries such as ophthalmic operations or complicated life-saving surgery, where a patient must be transported from one hospital or institution to another, and the AW609 is ideal in this respect.

In Australia, the Royal Flying Doctor Service (RFDS) flies a range of single and multi-engine fixed-wing aircraft which serve remote communities in the outback. Its missions range from flying in general practitioners, nurses and other medical assistants to check on a community, to emergency response and aeromedical evacuation.

For the latter they will fly from the outback to an airfield/airport closest to a major hospital and there await either ground transportation by ambulance or an airlift by helicopter. Sunick noted if extreme bad weather were to strike in an area where the RFDS was urgently needed, the ground could become unsuitable, making it difficult, if not impossible, to land a fixed-wing aircraft.

The AW609 could provide a solution by landing vertically, picking up the patient and flying directly to a hospital helipad, removing the time taken to transfer to either ground ambulance or helicopter.

Another mission the AW609 can cover is offshore search and rescue (SAR), for which the helicopter can fly out and cover a radius of 250 nautical miles (463km) in one hour, matching the speed of many fixed-wing search aircraft. Leonardo's tiltrotor could immediately transition into a hover and

AW609 characteristics

Length	13.4m (44ft)
Wingspan	10m (32ft 10in), distance between prop-rotor centres
Width	18.29m (60ft), turning rotors
Height	4.6m (15ft 1in), to top of fin
Main rotor diameter	7.7m (25ft 11in)
Main rotor area	49m ² (530ft ²)
Cabin height	1.42m (4ft 8in)
Cabin width	1.47m (4ft 10in)
Cabin length	4.09m (13ft 5in)
Baggage compartment	1.41m ³ (49.7ft ³)
Crew	2
Passengers	9
Empty weight	4,765kg (10,505lb)
Max take-off weight	7,620kg (16,799lb)
Useful load	2,860kg (6,305lb)
Hover out of ground effect (ISA)	6,000ft
Hover in ground effect (ISA)	10,000ft
Service ceiling (ISA)	25,000ft
Max range with auxiliary fuel	1,000 nautical miles (1,850km)
Max range without auxiliary fuel	750 nautical miles (1,390km)
Max endurance without fuel reserve	3 hours
Max cruise speed	275kts (510km/h)
Rate of climb	1,500ft/min (7.6m/sec)
Engines	Two Pratt & Whitney PWC PT6A-67A each generating 1,940shp (1,447kW)
Data: Leonardo	



N609TR, wearing its previous colour scheme, photographed during a demonstration flight at Heli Expo in 2014.

Ian Frain

execute a winch rescue to those in need. Additionally, the AW609's pressurised cabin and smooth high-altitude flight is ideal for medical personnel to administer treatment to patients in the air, in either the single or dual stretcher configurations.

At the Dubai Airshow in November 2017, Leonardo displayed a mock-up of the AW609 in an updated parapublic/EMS/SAR configuration. One noticeable change was the main access door, where the hinge locations were changed to enable the door to open as a hatch instead of opening outwards. This means the door can open more widely, making it easier for the SAR crew/winch operator to manoeuvre the accident victim or patient, who may be on a stretcher, into the cabin.

Corporate and executive market

In business there is an old saying that time is money and it is true that businesspeople, decision-makers and corporate executives often need to be somewhere rapidly. That place could be far away in the middle of nowhere or in a town/city in a faraway state or county, or even in another country (obviously the latter would need the combined use of a corporate jet or other fixed-wing aircraft and helicopter).

Sunick said large companies' corporate flight departments employing both helicopters and executive aircraft (be it turboprop or jet) are under financial scrutiny in the current economic climate. It is estimated that United States corporate charter operators fly approximately 382 nautical miles' (707km) distance with an average of four passengers, and in Europe it works out at 372 nautical miles (689km) with four passengers.

In terms of maximising the cost of operation, the AW609 could be a good business tool by replacing both rotary-wing and fixed-wing in a company's flight department. To give an example, if there was a chief executive who needed to be in New York at the opening of the Stock Exchange first thing in the morning, but they lived a considerable distance from the city, then an AW609 could fly them from anywhere within a radius of several hundred nautical miles

directly into Manhattan Heliport faster than a conventional rotorcraft.

Another example could be someone who lives in the UK but wants to spend a weekend in Monte Carlo. Currently they have to fly to Nice International Airport then take a car to complete their journey, whereas the AW609 can fly the 560 nautical miles distance from London City Airport to Monte Carlo directly in approximately two hours and 20 minutes.

Climbing higher

In recent years, there have been many modifications and changes to the AW609 such as the cabin door changes and there is a new landing gear on the airframe. In terms of performance, there are the more powerful Pratt & Whitney PT6 engines that generate approximately 1,940shp (1,446kW) as well as aerodynamic improvements yielding approximately a 10% reduction in drag. If there is a desire for greater range, then there are options to install external fuel pods.

At the heart of the AW609 is a triple-redundant, fully-digital fly-by-wire flight control system, supplied by BAE Systems. Rockwell Collins Proline Fusion avionics provide all-round situational awareness and reduce the pilot's workload. There are 14in (355mm) touchscreen displays and integrated flight management systems with satellite-based navigation, synthetic and enhanced vision systems integrated with the AW609 avionics management. The upgraded flight control computer uses an air data system with a similar architecture to those systems installed on the Leonardo family of helicopters.

In terms of flying, Sunick said the AW609 in conventional aircraft mode is like handling a Beechcraft King Air twin-engine turboprop. There are several reasons why, with both aircraft being of a similar size and that the flight control software on both the AW609 and King Air utilise Pratt & Whitney PT6 engines. **AI**



In search and rescue configuration the AW609's pressurised cabin allows space for medical personnel to administer treatment to patients in either the single or dual stretcher configurations. Ian Frain

Assigned to Commando Helicopter Force (CHF), 845 Naval Air Squadron (NAS) embarked aboard HMS Queen Elizabeth on August 20, 2018, with three upgraded Merlin HC4 helicopters and approximately 90 personnel. Premise for the deployment was to support the carrier's first-of-class F-35B flight deck trials and the ability to work with other nations' maritime forces. This included the landing of Royal Marines and their equipment ashore in the United States, and to conduct training with its US counterparts.

The squadron had four specific roles:

- Deployed search and rescue (DSAR) should an F-35B encounter an emergency whilst conducting flying trials
- Maritime intra-theatre lift (MITEL), which involves the movement of cargo and personnel around the maritime task group

- Joint personnel recovery (JPR) capability,
- To develop tactically littoral manoeuvres (LitM)

Embarkation and involvement was not intended solely to generate helicopter ops, but to hone aircrew skills in picking up a pilot in the event an F-35B ditched during a trial, or was shot down behind enemy lines in a simulated scenario. Training was conducted alongside US Marine Corps personnel from Marine Corps Base Quantico, Virginia.

Initial challenges

From the outset, media and political attention was naturally focused on the historic first landing and the F-35B flight trials aboard HMS Queen Elizabeth. The three 845 NAS Merlin HC4s and three 820 NAS Merlin HM2s played a vital role in the series of trials.

In the months preceding this historic event, CHF and 845 NAS had been working hard

to ensure its new Merlin helicopters could embark as planned.

Embarkation was uncertain caused by a delay with delivery of the first Merlin HC4 from early 2018 to May 24. Further delays ensued as the release to service (RTS) for the first aircraft was not received until mid-June. Qualified helicopter instructors were trained by Leonardo Helicopters, which delivered a conversion package for the squadron only weeks before deployment. It was touch and go whether the aircraft would be ready. Cdr Bond said: "WESTLANT 18 had been years in the making. Our major concern was our inheritance of the Merlin HC3, Merlin HC3A, which required a major upgrade [to HC4 standard] and that configuration may not have been ready for the first deployment. Our approach from the outset was to deliver a reliable DSAR capability without compromising

HMS Queen Elizabeth off Cornwall's southern coastline on December 9, 2018 bound for Portsmouth.



Elizabeth

safety. Quite simply, if we were not ready we would not go. As it became clear there would be delays with the HC4, we decided to complete our DSAR training on our HC3As and then convert aircrew once the HC4 obtained its RTS on August 18, 2018. This period was fraught, extremely challenging, but ultimately very rewarding. It was therefore a proud moment on August 20 as the squadron embarked three brand-new HC4s when six months earlier the expectation was the HC4 would likely not be ready. To train and qualify aircrew in the areas required in such a short space of time was a fantastic achievement, which was recognised throughout the Royal Navy."

Transition

Converting from the Merlin HC3 and Merlin HC3A to the HC4 involved approximately six flights. Aircrew had few problems

converting; the key issue was understanding the aircraft's new touchscreen digital cockpit. In June 2018, 845 NAS embarked HMS Queen Elizabeth with two Merlin HC3As and its entire flight. Cdr Bond said: "This proved a significant move as it enabled the squadron to integrate with the ship, to understand its operation, complete some DSAR training and effectively de-risk the August embarkation."

According to Cdr Bond, within weeks of embarkation the squadron had completed its deck training and declared DSAR full operational capability on September 5. He said: "Prior to embarkation of the jets, we had time to understand how we were going to operate on the deck, including the folding of the aircraft and how the hangar worked, all the while working towards generating a decent deck tempo, which would be crucial. This was an evolutionary,

bordering on trailblazing, process. There was no manual, we had to determine what worked and what didn't to establish our standard operating procedures, which would potentially last decades."

Providing MITEL, moving people and cargo around the maritime task group and ashore, was pivotal to the successful achievement of the trials. God forbid any of the test pilots should need to eject, 845 was on call 24/7 to support them and the near 200 ITF personnel aboard for the trials. This logistics support included routine 150 nautical mile (240km) flights to shore to maintain mission continuity. The squadron's success can be measured by the results of the trials; the objectives of Developmental Test periods DT 1 and DT 2 were achieved, as well as elements of DT 3 and components of Operational Test period OT 1 in advance of WESTLANT 19.



Kevin Wills and Ian Harding went aboard HMS Queen Elizabeth prior to its port homecoming, to find out about a cruise to the US eastern seaboard and the sterling work undertaken by Merlin HC4-equipped 845 Naval Air Squadron

n returns



First-of-class trials

Merlin's were airborne throughout each F-35B flight to provide DSAR. The squadron skipper said there were generally two operational test periods per day, each lasting two to three hours. For the duration of the missions, 845's Merlins were held in the hover next to the ship waiting to respond to any incident with another on deck standby, a role known as plane guard. Afternoon missions were often extended into the evening, with 845 NAS aircrew flying long hours; Merlin was often the last aircraft to land. Any MITEL requirements generally took place before the F-35B trials commenced, but as the trials developed, other rotary assets were able to operate generating a busy flight deck.

Maritime configured Merlin

The Merlin continues to prove its worth at sea. It is considered the aircraft of choice both in terms of its capability and safety. In Cdr Bond's opinion, if you designed a maritime support helicopter it would be the Merlin HC4.

He said: "It provides the Royal Navy with the highest levels of utility in the maritime environment and is optimised for amphibious operations delivering Royal Marines from the ship to shore. Boasting a folding head and tail, we were able to operate this capability whilst on board. You can fit three Merlin's in the same space required by a Chinook, which is an important consideration when operational space is limited above and below deck. Merlin HC4 is fully configured for maritime ops and can withstand the exposure to the harsh environmental conditions for long periods of time."

These trials provided 845 NAS and 820 NAS with the perfect opportunity to showcase Merlin's utility and potential. From CHF's perspective, this includes the development of an aerial refuelling capability (already successfully trialled by Leonardo) to extend operational range, plus the introduction of an M3M machine gun and secure datalink communication (already installed in the Merlin HM2).

UK F-35Bs will operate at distance from the carrier and the MoD will need a capability potentially to extract aircrew from behind enemy lines. CHF and 845 NAS are well rehearsed in this role, having worked closely for the past two years with 42 Commando, Lima Company which is the UK's ground extraction force. This included participation in the European Air Centric Personnel Recovery Operatives' Course 2018 held in the Netherlands.

Bond explained that the squadron know the JPR requirement is being developed by the MoD and that the unit wanted to get ahead of the game and generate this capability. He said: "Tactically, we are in a good position as we have worked extensively with Royal Marines, with both elements understanding exactly what they need to do when we lift from the ship. Of course, we need to enhance the capability in terms of fixed-wing support [and] close air support and we need to consider ways we can supplement the existing capability with Wildcats, for example. We also need to extend our radius of action from the carrier, hence the requirement for aerial refuelling. The Merlin has over three hours of endurance, but it will ultimately need more with our F-35Bs operating so far from the carrier. We have air-to-air refuelling probes; we just don't have the RTS at the moment. Secure communications are due to be fitted in the near term to ensure we can communicate with the commanders on board during live operations."

Future generation

Leonardo Helicopters will deliver 25 Merlin HC4s to CHF at RNAS Yeovilton by 2021. Under the current plan, 845 NAS will receive 12 aircraft with sister squadron 846 NAS (responsible for operational conversion training) receiving nine, with four planned to be in deep maintenance. Thus far, 845 NAS has received five HC4s, with 846 NAS receiving its first Merlin in February 2019. This will enable the squadron to prepare for a refresher Merlin conversion course in April 2019 and ab initio Merlin training.

Cdr Bond reckons that managing the complex transition process concurrently with delivering a range of capabilities to the fleet





Merlin HC4 ZJ121/E lifts off the flight deck on its return to Yeovilton. The nose marking applied to each of the 845 Squadron Merlin HC4s reminded everyone of the call sign and no doubt prowess.



is testing. He said: "During the next couple of years there will be various upgrades; tactical system enhancements, increased AUM [all up mass] and DAS [defensive aids suite], before we have a fully capable HC4 by 2021. We currently have five HC4s and three HC3As, so we are not too far away in pure numbers terms. Attention now turns to 846 NAS, [which needs] to generate HC4s and the qualified helicopter instructors required for Commando 1 [the first Merlin HC4 course] starting in 2020. Sister squadron 846 will be training many crews in the coming years, growing the force to initial operational capability in 2020 and FOC in 2023."

How many Merlins?

How the UK intends to use its two aircraft carriers in the future is still evolving and

ultimately will depend on their two roles: carrier strike (primary) and the future concept hybrid littoral strike (secondary). This would potentially incorporate a mix of F-35Bs and different types of helicopter, plus Royal Marines. This mix offers flexibility and the ability to switch from one operation to another. The Maritime Task Group could then facilitate a range of operations from humanitarian relief to high-end warfighting. Its size and the aircraft deployed would ultimately be determined by the scale of the threat and the strike force required to counter it. Broad consensus is three to four Merlin HC4s would be required to support regular DSAR and JPR, but this number could expand during LitM, with 845 NAS supporting 3 Commando and a wider field army, which is its core role. An

unknown number of Merlin HM2s will also be required to provide airborne surveillance and control, anti-submarine and anti-surface warfare capability.

CHF also includes the Wildcat-equipped 847 NAS and other specialised mobile units and is set up to provide an array of capability. CHF and its component units will be extremely busy during the coming years supporting a range of roles embodied within the carrier-enabled power projection concept, namely carrier strike group and LitM deployments. Discussing the core business of LitM, the squadron skipper said 845 will support 3 Commando Brigade and the littoral strike concept with Merlin HC4 and our amphibious expertise. He said: "Our return to the maritime and littoral environment after so many years of land-centric warfare is exciting." **AI**

Four Merlin HC4s on HMS Queen Elizabeth's flight deck prior to their departure back to Royal Naval Air Station Yeovilton.



In Greek mythology, Proteus was a sea god who changed shape at will and could predict the future. It is an apt name for the sole Scaled Composites Model 281 Proteus, which with its distinctive tandem wings and twin tails looks like very little else in commercial aviation.

Proteus was initially conceived as a high-altitude long-endurance (HALE) platform for telecommunications relay, but from the outset it was designed to carry different payloads in a variety of locations around the aircraft. Payloads can be changed relatively easily, meaning that like its mythological namesake the aircraft's form can change. The result is that Proteus is a multipurpose platform that can carry out different research roles, from atmospheric sampling and reconnaissance to commercial imaging and sensor testing.

It is now more than two decades since Proteus undertook its first flight from Mojave Air and Space Port in California on July 26, 1998, but the aircraft, N281PR (c/n 001), remains active and available for airborne research and testing.

Configuration

Proteus' twin-wing double-boom layout looks unconventional. The main landing gear legs are spread wide apart and mounted in the tail booms in the rear section of the aircraft, which also contains the 77ft 7in (23.6m) main wings, the two Williams International FJ44-2 turbofan engines and the vertical stabilisers. The forward section contains the pressurised cockpit, forward canards and nose landing gear.

Proteus was designed to cruise at altitudes from 50,000ft to more than 63,000ft for up to 18 hours. Sam Henney, Scaled Composites Proteus Product Engineer, explained to AIR International this operating environment drove the aircraft's unusual layout.

He said: "Because it's a high-altitude long-endurance platform you want long wings for efficiency. A lot of U-2 pilots talk about the stall up there at high altitude; it's called the 'coffin corner'. With Proteus' configuration, more of a flying wing configuration, you have stall protection, so we can fly very comfortably."

While Proteus looks unusual, what really makes it remarkable is the capability this layout provides. There is space for a barrel at the centre of the fuselage that, as it is well away from the wings, engines and other critical systems, can be modified quickly and easily to carry different instruments. The barrel can carry payloads of up to 2,000lb (907kg).

There are additional payload bays around the aircraft, including the nose, boom extensions, cabin and internal fuselage, and depending on the depth of the customer's instrument, external pods can also be mounted directly to the fuselage using custom interfaces. The main wings and forward canards are extendable, thanks to removable tips (the main wings can extend to 92ft/28m) that are used as required to tailor Proteus' handling according to the aerodynamic impact of the different external payloads.



*The Scaled Composites Proteus is a distinctive aircraft with a multipurpose capability.
Mark Broadbent profiles this unique platform*

Shape-shift

The small cabin is pressurised to an equivalent altitude of 14,500ft when the aircraft is at 55,000ft (or pressurised to a 15,500ft equivalent altitude at 60,000ft), giving the two-person flight crew – one pilot, one crewmember operating the payloads – a measure of comfort despite the high-altitude operating environment. In other manned HALE platforms such as the U-2 pilots wear pressure suits; in Proteus, the crews are in shirt sleeves.

Proteus is a largely composite (graphite-epoxy sandwich) structure, although one of the removable wingtips is fibreglass, and the crew compartment has grid-stiffened solid laminate construction. The retractable tricycle landing gear is electro-hydraulically powered and the nosewheel steering is manually actuated by the crew's rudder pedals. The

flight controls operate on a conventional mechanical pushrod/cable system with sidestick controllers.

A user guide for the aircraft produced by Scaled Composites says Proteus' autopilot can hold inertial or pressure altitudes to the accuracy of a couple of feet and, when coupled with the aircraft's Garmin global navigation system (GNS), provides accurate course guidance to within a few hundred feet.

Semi-autonomous

Proteus has a semi-autonomous capability. The crew can fly the take-off, climb, descent and landing, but the aircraft can be operated on station at mission altitude remotely. There is a two-axis autopilot for hands-off flying when on station.

This capability resulted from co-operation between Scaled Composites and NASA's Armstrong (formerly Dryden) Flight Research Center under the Environmental Research Aircraft and Sensor Technology (ERAST) programme, a NASA initiative that ran from 1994 to 2003 to develop new technologies for remotely operated systems.

NASA was interested in Proteus from the aircraft's earliest days, according to Henney: "Proteus came about the same time as the Global Hawk, so for NASA it was a great platform to explore high-altitude long-endurance [flight] at a really low cost."



More than 30 payloads have been carried by Proteus, many for various NASA projects.
All photos Scaled Composites

The primary focus of ERAST was to develop slow-flying unmanned systems able to perform long-duration science missions at altitudes above 60,000ft, such as remote sensing for earth sciences studies, hyperspectral imaging for agriculture monitoring, tracking of severe storms and serving as telecommunications relays.

As well as the station-keeping autopilot system, the ERAST project also funded the development of a satellite communications-based (satcom) uplink/downlink data system for aircraft and payload data, giving Proteus a full over-the-horizon capability.

This enables the aircraft to be controlled remotely from a distant ground-based control station via the satcom uplink/downlink and serve as a surrogate UAV in 'detect, see and avoid' flight test campaigns involving both cooperative, transponder-equipped and non-cooperative, non-transponder-equipped aircraft.

NASA projects

NASA was the exclusive user of the aircraft for several years, flying it in many configurations with different payloads for various research projects beyond ERAST.

Early in 1999, Proteus carried an operating science-imaging payload, the Airborne Real-Time Imaging System, which was operated remotely by the flight crew and took visual and near-infrared photos of the California desert and provided near-real time images to a ground station from an altitude of 50,000ft.

NASA's Office of Earth Science, joined by the National Oceanic and Atmospheric Administration and the Department of Defense, subsequently funded a series of flights as part of its evaluation of Proteus as an airborne platform for atmospheric science and remote sensing missions at altitudes up to 60,000ft.

The result, in October 2000, was Proteus setting three world altitude records over California's high desert for Class C-1E, Group III aircraft (those with gross weights of 12,500lb/5,669kg or less). These were a peak altitude of 63,245ft, sustained horizontal flight at 62,385ft and a peak altitude of 55,994ft while carrying a 2,204lb (1,000kg) payload.

Other NASA research missions in which Proteus was involved included the Transport and Chemical Evolution over

Proteus' tandem-wing and twin-boom configuration helps to create space for carrying pods to the existing centreline belly pylon. There are additional payload bays around the aircraft.



the Pacific) mission above the North Pole, the Chesapeake Lighthouse and Aircraft Measurements for Satellites programme to measure ocean characteristics and the Crystal-FACE (Cirrus Regional Study of Tropical Anvils and Cirrus Layers-Florida Area Cirrus Experiment) campaign.

As Scaled Composites maintains and flies Proteus, the company has over time opened access to the aircraft to other customers beyond NASA and it is available for research and evaluation to support science campaigns and test new flight systems.

Among others, Angel Technologies and Raytheon used the aircraft to test a 1,100lb (499kg) telecommunications dish measuring 13ft (4m) in diameter by 3ft (0.9m) in depth; a joint US Department of Energy and Sandia National Laboratories programme saw Proteus equipped with sensors to study cirrus in the upper atmosphere; while the US Air Force used the aircraft for its Multi-Platform Radar Technology Insertion Program and Airborne Laser projects.

Proteus has been very well-used over the last two decades: it has carried around 30 different payloads and amassed more than 4,000 flying hours. Henney noted Scaled Composites originally intended to use the

aircraft only for a couple of hundred flying hours as a proof-of-concept demonstrator, and the fact that it has been used far more than first planned is perhaps the ultimate testament to its capabilities.

Payload integration

How are new payloads put on to Proteus? As the aircraft's designer, manufacturer and operator, Scaled Composites says it is "extremely flexible when it comes to payload integration and has the ability to rapidly accommodate many customers' requirements".

According to the company's user guide, a typical flight test for a payload consists of the following stages: pod design, pod fabrication, sensor/system integration, ground testing, flight-test planning, payload checkout flights and data collection/demonstration flights.

The company's engineers and technicians work with a client to understand its objectives, asking tailored questions to define the scope of the testing effort, before going through the phases from design to data collection.

Scaled Composites stresses the availability of the aircraft: "Due to the modular payload approach, changing payloads can be a simple task. This capability enables [the company] to support multiple customers during concurrent test programmes."

With Proteus offering a modular capability, power is an important aspect of the aircraft. Electrical connections from the front and rear fuselage sections provide power lines for the payloads in the belly and the other locations.

There are two starter/generators supplying up to 800 amps of 28-volt direct current (although output is nominally limited to 200 amps per starter/generator to preserve life) and inverters. A 55-pin 38999 connector and two ethernet connections provide the crew with the ability to control payloads. The Scaled Composites user guide says: "Everything from custom boxes to PC laptops have been used for payload interface and control."

Other systems aboard are two VHF (118.000–136.975MHz) radios and one UHF (225.000–399.975MHz) radio providing line of sight communication within approximately 150 nautical miles (277km) of a base station radio and a bi-directional line of sight data link (rated at up to 4.5Mb per second).



Scaled Composites Proteus, used for airborne research and systems testing, presents a unique profile from any angle.

A NovAtel SPAN GPS-aided inertial navigation system mounted in the lower cabin forward of the aft pressure bulkhead shows attitude, position and rate information over serial data lines, which is collected by an onboard data acquisition system.

Navigational information is provided by all-in-one GPS/navigation/communications packages in the form of two Garmin GNS units. A GPS source splitter provides GPS signals to the various aircraft payloads, receiving its signal from a Sensor Systems Antenna P/N S67-1575-39. If necessary, other GPS antennas can be adapted to existing mounts on top of the fuselage.

Future usage

In the time Proteus has been flying, there have of course been significant advancements in HALE operations with the evolution of unmanned systems. Most obviously there is the Northrop Grumman RQ-4 Global Hawk, but a brace of new unmanned HALE systems such as the Airbus Zephyr HAPS and Aurora Flight Sciences Odysseus is emerging from the commercial sector just now.

These and other pseudo-satellite systems are being designed to offer persistent

Proteus pictured carrying a payload for the US Air Force Multi-Platform Radar Technology Insertion Program.



capabilities in surveillance, reconnaissance, commercial imaging and communications relay – exactly the type of work for which Proteus is designed. A question therefore arises: what is the future for this aircraft?

Scaled Composites firmly believes Proteus still has a role. Henney said customers can deploy systems on Proteus more easily than on an unmanned system: “The high-altitude, long-endurance regime is complex and expensive. It’s actually cheaper to operate a platform manned than unmanned [and] you can develop autonomous systems much more safely and cheaply.”

Henney added unmanned systems for the HALE environment generally require more resources on the ground in flight support and engineering. He said: “The number of people it takes to operate an unmanned platform is a lot compared to Proteus. It’s built like a general aviation aircraft: very simple systems. We can go all over the world with a team of three or four. There are savings right there.”

Despite the new generation of high-flying unmanned systems, therefore, the shape-shifting Proteus is likely to remain in the skies. Moreover, Henney told AIR International the aircraft continues to be well-used: “Generally, we don’t share what our customers are up to unless they want us to. I can say though that the aircraft is busy; we fly multiple customers a year, three, four or five payloads. We’re busy all this year and into next year. It remains a cost-competitive and relevant platform.” **AI**

Proteus characteristics	
Wingspan	77ft 7in (23.6m) or 92ft (28m) with removable tips installed
Wing area	300ft² (27.8m²)
Canard span	54ft 7in (16.6m) or 64ft 7in (19.7m) with removable tips installed
Canard area	178ft 7in² (16.6m²)
Length	56ft 3in (17.1m)
Height	17ft 6in (5.3m) on landing gear
Empty weight	5,900lb (2,676kg)
Max take-off weight	12,500lb (5,669kg) or 15,800lb (7,166kg) in military usage
Fuel capacity	6,000lb (2,721kg) in fuselage, canard and wing tanks
Take-off distance	2,500ft (762m) at max take-off weight
Payload	1,800–7,260lb (816–3,293kg) depending on mission
Speed	190kts (351km/h) at 20,000ft, 280kts (518km/h) at 40,000ft, Mach 0.42 at cruise
Climb rate	6,000ft/min (30m/s) at 8,000lb (3,628kg) or 3,400ft/min (17m/s) at 12,500lb (5,669kg)
Endurance	Up to 18 hours depending on payload and altitude
Ceiling	Up to 65,000ft at 7,000lb (3,175kg) or 58,000ft at 12,500lb (5,669kg)
Crew	Two (one pilot, one operator)
Engines	Two Williams Research/Rolls-Royce FJ44-2 turbofan engines, each generating 2,300lb (10,230kN) thrust

Data: Scaled Composites

Scaled Composites says Proteus remains a cost-effective, flexible test platform.



The Royal Air Force's 47 Squadron based at RAF Brize Norton, Oxfordshire has provided the backbone of the United Kingdom's operational tactical airlift capability since the C-130J Hercules entered service in 1999. Tasked at the sharp end of enduring operations including Operations Telic, Herrick and now Shader throughout the last 20 years, the squadron has won many plaudits for its 'can-do attitude'. Official recognition came on October 10, 2017, an announcement was made that 47 Squadron was the only Royal Air Force unit awarded the right to emblazon battle honours for both Iraq 2003-2011 (Operation Telic) and Libya 2011 (Operation Deference).

In a perfect example of the squadron's flexibility, Operation Deference saw 47 Squadron switch its operations at short notice

from Tripoli, Libya's capital, to remote parts of the desert to evacuate both United Kingdom and other civilians who had become trapped as the conflict escalated.

During AIR International's visit to Brize the author spoke with various officers serving on the squadron including the second-in-command (2IC), a Hercules pilot for eleven years. Together they discussed the unit's current roles. Names have been withheld for security reasons.

Forward fleet

At the time of writing, 47 Squadron's establishment comprised 17 Hercules; 13 Hercules C4s (C-130J-30s) and four Hercules C5s, (the shorter C-130J). The forward fleet comprises 12 aircraft with the remainder in maintenance; ten are prepared for operations

at Brize Norton with two deployed. The 2IC confirmed the total fleet will reduce to 14 aircraft from April 2019 comprising 12 C4s and two C5s. Respectively, the forward fleet will then comprise ten aircraft available and prepared for operations; eight at Brize Norton and two deployed elsewhere. Buyers have already been found for three former aircraft. The current fleet amassed 8,000 flying hours in 2018 as budgeted, which will reduce to 7,000 annual flying hours from April 2019 as aircraft numbers decline. Flying operations will remain broadly consistent year-on-year.

Fleet management

Following much conjecture, the RAF Hercules out of service date has been confirmed as 2035. This was extended following the announcement by the Ministry of Defence on



July 14, 2017 of a major upgrade programme valued at £110 million. This will involve installation of extended service life centre wing box kits on the fleet's remaining aircraft by Marshall Aerospace and Defence Group based at Cambridge airport.

An extended service life centre wing box gives an estimated life two-to-three times greater than the original centre wing box. Other modification programmes remain ongoing. One, being installed at Brize is an enhanced identification friend or foe system mandated for aircraft using civilian airspace from 2020 dubbed FOMS (freedom of movement system). The first FOMS-modified aircraft was received in October 2018 with aircrew training commencing immediately after.

Other upgrades are likely to include some of the systems in the Block 8.1 configuration

initiated by Lockheed Martin in consultation with the C-130J Joint User Group of which the UK is a member. Block 8.1 is the latest baseline upgrade designed to ensure interoperability and compatibility with the latest civil air traffic management regulations, and adds ten new capabilities facilitated by software and hardware improvements.

Lockheed Martin told AIR International that Block 8.1 updates include an updated identification friend or foe, Automatic Dependent Surveillance Broadcast, a CNS/ATM datalink, enhanced low-noise inter-communication system, enhanced approach and landing systems, enhanced diagnostics, covert infrared landing lights, a traffic collision and avoidance system, a terrain awareness and warning system, and an improved public address system.

Lockheed Martin's Marietta-based C-130 division also confirmed that participating JUG nations all provide input into the Block upgrade development process, but do not automatically receive a Block upgrade. Operators, including the UK, can choose to receive the full Block upgrade or portions of the Block upgrade. Incorporation of updates is dependent on each country's needs, budgets and timelines.

Fleet management is vital given the squadron's tactical operations specialisation. The Hercules fleet rapidly accumulated more flying hours than projected during Operations Telic and Herrick, so every effort is made to ensure tasking is spread across the fleet to manage airframe fatigue. This is essential to ensure each aircraft meets its entry date to the centre wing box replacement programme.

No fear of the dark

Ian Harding visited 47 Squadron, the final unit in the Royal Air Force to operate the C-130 Hercules, and learned a lot about its tactical airlift capability

Hercules C4 ZH868 trails a second Herk in the golden light of an English afternoon.
38 Group/Royal Air Force



For example, any aircraft with higher hours would not be the first to be selected for UK low-level flying or exercise participation during which a higher number of hours will be accumulated. When considering its options for sending a Hercules to Minahasa Peninsula, Indonesia following the earthquake and tsunami on September 28, 2018, a balance is required as the 2IC explained: "Considerations given in this situation include how quickly we need to get there and the specific roles to be performed when we arrive. There are advantages and disadvantages in sending either mark of aircraft. There's a benefit in sending a C5 because it doesn't have external tanks and it's therefore a couple of tonnes lighter. This will help if the airstrip is short, but it will take us longer to get there as it doesn't have the C4's endurance."

For the past 20 years, the operational tempo of the RAF C-130J fleet has been high and sustained during which engineers have played a critical, and increasing, role to manage the fleet's structural health, ensuring bespoke tasking modifications take place at both Brize and Marshall's in a timely fashion; this all undertaken

while planning for and implementing the fleet's centre wing box upgrade.

The squadron's SENG (Senior Engineering Officer) confirmed the first centre wing box has been assembled at Lockheed Martin's Marietta factory in Georgia. Despite complexity in the taskings performed and the lengthy engineering preparations often required for certain tasks, she confirmed the fleet's serviceability is being maintained at historically high levels. With live tasking information not available, she outlined how the preparation process might work in an exercise scenario: "A lot of the deep preparations undertaken for exercises are required to enable an aircraft to complete three to four disciplines. An aircraft on a tactical validation unit exercise, for example, may be required to conduct strip landings, natural surface and maritime operations, all of which create issues. An exercise like this may last three weeks and it may take a similar amount of time for us to recover the aircraft when it returns. Low-level maritime operations require extra engine work, and similarly for desert operations, which have recovery codes to follow. There is a lot of penalty maintenance as a result. We

do encounter issues as you would expect for a fleet which has been worked so hard, but the great thing about the aircraft is that it has inbuilt system redundancy enabling it to be flown safely even with minor issues."

Flying with minor issues might be necessary given the role and tasking as the 2IC explained: "Out in the field, the decision to do that [fly with minor issues] is always risk-based and would only result following interaction between the crew and the supervisory chain. If a decision has to be made immediately, crews are empowered to make those decisions. When we can fix the aircraft we do, but when we have to undertake operations, we make pretty good risk assessments."

Crew complement

The Hercules Force has approximately 30 crews. Traditionally, each crew comprises two pilots, one weapons system operator and one aircraft ground engineer. Approximately 25% of the crews are instructors. Despite the anticipated fleet reduction from April 2019, a reduction in the number of aircrew is not anticipated. While a basic aircrew complement for deployed



ops is four, the squadron's operational tasking requires more, and requirements have changed as the 2IC explained: "For the majority of our operational tasks, we now fly with a crew of six; two pilots, weapons system operators and aircraft engineers. It is important to note that the engineers are an integral part of the crew and we cannot fly without them because they have specific roles depending on location: we require more eyes on the aircraft, and we need them to fix the aircraft quickly if it becomes unserviceable in a location where we need to move troops safely and quickly, or if the aircraft is required for operations the following night."

Complex tasking means aircrew must undertake contingency management, which has technical and psychological implications, and those associated with flying.

A crew of six is now considered necessary given the pressures felt by the aircrew working on the flight deck and in the rear of the aircraft as the 2IC explained. "Flying the aircraft is easy, the challenging part is flying across time zones, getting to the right point at the right time and then doing what we need to do in complex environments. At home, low-level operations are

challenging because UK airspace is congested, and the increasing number of civilian drones complicates matters. Our crew size is scalable but with a defined process applied. Having an additional person on the flight deck is critical to the way we now operate. In a low-level environment, we need a weapons system operator upfront. If we're doing an air drop at the same time, depending on the size of the load, we need one or two weapons system operators down the back. The bulk of the work is done before we get airborne; loading and planning. The despatch itself takes only a few minutes. We have one weapons system operator who deals with the load on and load off or air despatch, and the other is providing the link between the front and rear of the aircraft."

Weapons system operator mission preparation

A significant number of intra-theatre flights undertaken by 47 Squadron take place under the cover of darkness to reduce the threat of attack and because airspace is generally less congested at night. No matter what the conditions, weapons system operators must be

ready for anything, coordinating an increasing number of niche disciplines within a new operational paradigm. AIR International spoke with a weapons system operator with more than 20 years' experience on other multi-engine aircraft before moving to the Hercules. He said: "Today, we have to introduce the idea of a two-person weapons system operator formation much earlier in training. In its simplest form, one will work with the two pilots up front; assisting with observation, providing another set of eyes, helping with radio communication, whilst the other manages the cargo bay duties. We mix experience in training to build this. That said, the formation ultimately depends on where we are and what we are doing, especially with more niche roles, which include air despatch of boats, larger cargo or paratroopers. These require at least two weapons system operators. Only smaller packages can be managed by a single weapons system operator. Niche loads require more manipulation of the Container Delivery System [CDS] in the cargo bay; one to manipulate the CDS, the other to manage the load. Releasing a boat is our most complicated discipline. Space is extremely limited when you

Hercules C4 ZH868 air drops cargo bundles at low-level on the Salisbury Plain Training Area.

Ian Harding



place two large boats and a number of troops down the back. You have to be 100% focused on the space around you and who is where at certain times in the drop. Engine running offloads on the ground are no easier, especially during contingent operations where time is a premium and the threat level is high: some of our most challenging operations. As soon as you remove sound and the ability to speak, situational awareness declines and it becomes very difficult at both ends of the aircraft. It can be very unnerving for the guys at the front having no narrative and knowing we may need to move quickly."

In August 2014, 47 Squadron Hercules launched from the United Kingdom and RAF Akrotiri, Cyprus to airdrop aid (water, water filters, shelters) to the Yazidi refugees who had assembled on top of Mount Sinjar in northern Iraq. These missions were a matter of life and death, and highlight the nature of such a tasking as the senior weapon systems operator explained: "In terms of the airdrops, they were relatively straightforward, but then you must recognize they took place at night, at low-level, over one of the most dangerous environments, plus RAF C-130Js were the first aircraft to drop. The first mission was launched and executed within approximately 36 hours starting from Brize Norton. It involved a COMAO [composite air operation] package, international coordination to determine precise timings over the drop zone plus we had to air-refuel from an RAF Voyager en route. We had extra aircrew on the flight deck and looking out of the aircraft. There wasn't much space in the back and it was dark. This reflects what the squadron is set up to do alongside supporting ground units and our green Army during enduring operations.

"A similar but very different example was our involvement during Operation Ruman in September 2017 when RAF C-130Js delivered

aid into some short airstrips following Hurricane Irma, which hit various Caribbean Islands."

United Kingdom C-130 operations may be less demanding in terms of the threat level, but their execution can be equally challenging as the 2IC Sqn highlighted: "On an airdrop during Exercise Joint Warrior 2018, I had three people on the flight deck talking with three different coordinating agencies; the drop zone safety officer providing permission to drop, range safety officer and an airspace controller. It was a case of everyone focused on their job and then; clear, clear, clear, drop. A lot of effort for a few minutes' work."

Training

The squadron expects to recruit six to eight pilots and four to six weapon systems operators each year. Once 30 Squadron stood down as a Hercules unit at the end of 2016, 47 Squadron's training commitment changed significantly. Ab-initio flight crew arriving from XXIV Squadron, the RAF's operational conversion unit for all transport types, require further training, so consequently, the training programme is now streamlined.

After completing initial training with XXIV Squadron, pilots generally take two years to become fully mission qualified. Weapon systems operators can take longer to similarly qualify, as long as four to five years.

Nor can experienced aircrew rest on their laurels because new tasking may require trials followed by new training. For example, a recent heavy landing trial conducted by the heavy aircraft test and evaluation unit 206 Squadron, necessitated by a heavy landing incident, concluded in May 2018. A Hercules C4 operated from an austere landing strip on the Salisbury Plain Training Area to evaluate the current technique used for landing on unprepared strips; in particular the rate of descent used during

the final stages of landing, which could not be guaranteed. The trial was a success and 47 Squadron now trains for, and uses, the updated technique operationally.

There are also ramifications for the type of person 47 Squadron seeks to recruit given its tactical role as the 2IC explained: "Everyone who now arrives on the fleet must have the capability of becoming a fully mission qualified pilot or weapon systems operator. Our recruitment must therefore start earlier during training at RAF Cranwell [RAF Cranwell, Lincolnshire is home to the Royal Air Force College]. Our challenge is ensuring that those interested must be capable of doing the job, must be assessed appropriately at an early stage of training plus they must be aware of what they're coming in to. We need to identify individuals who are robust characters due to the environment we work in because we need them to be able to look after themselves, operate remotely with less supervision, work well with the team, motivate their peer group as well and demonstrate leadership qualities from the moment they arrive here.

"We get very capable individuals, but we can't simply force the required experience on them, especially now. We throw a lot at them, we know what our crews need to do at the high end and we know what standard they're at but bridging that gap is difficult. Core competencies at the high end include low-level formation flying, and tactical airdrops."

Engineering demands

The engineering model currently used has changed dramatically from the one used by Hercules squadrons based at nearby RAF Lyneham, Wiltshire; its evolution began to change once 47 Squadron moved to Brize in 2011.

A deployable team of ground engineers currently comprises approximately 30 personnel who now work on a similar contingency footing

Heading out on a mission from Brize Norton, Hercules C4 ZH866. This shot shows the antenna array fitted to the underside fuselage of this aircraft, a fit that appears on other RAF Herks. *Ian Harding*



as the pilots and weapon systems operators. Discussing the key role undertaken by the engineers in 47 Squadron's intra-theatre operations, the SENG described the ongoing commitment to Operation Shader as the only forward deployed engineering capability since its maritime patrol support to Operation Kipion, the UK's long-standing maritime presence in the Persian Gulf and Indian Ocean was reduced. Shader involves two aircraft and four engineers whose role is predominantly to fly with the aircraft on operations, and be available to service the aircraft if anything goes wrong during a mission or to forward deploy with the aircraft as required.

She said: "We have a pool of personnel spread across a day or night shift to deal with issues depending on where the work is coming from, or the times aircraft are moving. The line used to work a typical four days on, four days off, 24/7. Now we have a day-night shift pattern, with a swing night shift which provides only limited 24/7 cover at Brize from 02:00hrs.

"We also work a more flexible work pattern since our strategic lift role has been reduced; we have to roll and move with the punches so to speak. As the engineer's job has become more complex and demanding, my greatest challenge is ensuring all my engineers are suitably qualified to meet the requirements made of them. It used to take 12 months for an engineer to get out on the road, it now takes 18 months with the extra courses we have to take, and the new regulations, which are more in line with those of the Civil Aviation Authority. This is challenging.

"In the past we would have taken a spare wheel with us and one engineer would have changed it and signed it off. Now, if we burst a tyre in an austere location our priority is to change it and get out to safeguard the crew and those we are deployed with. We therefore have to find the right balance, to include

training since we lost the experience that Operation Herrick provided. This was an easier detachment, plus we had other routes with it. We can't train guys during live tasking, so we have to obtain the maximum benefit from training operations we have."

In addition to the day-to-day flight maintenance completed by 47 Squadron at Brize, Marshall Aerospace and Defence Group manage Hercules heavy rectifications in Hangar 94; a purpose-built facility capable of housing two aircraft and used to complete in-depth maintenance tasks and exercise recovery work. Marshall Aerospace has supported the RAF Hercules fleet for over 50 years.

Operations

Typical months of operations don't tend to happen on 47 Squadron; the unit provides tactical more than strategic airlift, moving people and cargo to where it needs to be. That said the unit has to train for both. UK flight operations are most likely staged in preparation to support tactical units in intra-theatre operations.

The squadron's work is varied; one day it could involve dropping high-altitude paratroopers, the next day low-level formation flying in Wales or Scotland, or undertaking ground training simulation for loading a boat: individuals do more now than ever before.

Aircrew confirmed the tempo of operations has not changed since Operation Herrick concluded in December 2014, but its diversity has increased. Commitment to Herrick simply rolled into Operation Shader [the UK's operation against ISIS] with a change in the threat level of contingent ops. Truth is, 47 Squadron has always been involved in contingent operations, involving aircraft and crews deploying quickly on specific missions. Today the C-130 fleet is smaller and its roles are more specialized, so

things are different as the 2IC explained: "At the highpoint of Operation Herrick, we had four to five aircraft deployed [in Afghanistan], one in the broader Middle East and one in the Falkland Islands. Aircrew were detached perhaps once every three to four months. Rewind to Operation Telic when the fleet was expanding, and some aircrew were spending four to five months deployed each year. Today's situation is more sustainable with aircrew, which includes engineers, on detachment perhaps twice per year, completing one to two exercises per year within the UK and one overseas. The rest of their time is considered normal flying."

With its fleet reducing to 14 from April 2019, 47 Squadron appears to be just about sufficiently equipped to meet its current commitments but not much else. It has personnel with the knowledge and experience to meet the specialist demands made of them, and it is structured to do so. Every effort is being made to flex what the squadron does during exercises and in training to ensure all personnel and aircrew gain the right experience at the right time.

Training methods used by other C-130J operators, particularly the use of ground-based training systems, are being examined with the aim of reducing high-end flying hours.

Today, 47's ongoing major challenge is recruiting the right type of people and having the means to train to meet niche tasking requirements. Any squadron or unit involved in tactical operations does so at the edge of the operating envelope in complex situations where timely risk-informed decision making by operators and the chain of command are essential to achieve military objectives. No real quibble about that; 47 Squadron has been continuously deployed on operations for the last 36 years no doubt living up to the words *Sans Peur*, its unofficial motto meaning without fear. **AI**

Large orders at Heli-Expo

AIRBUS HELICOPTERS ended the 2019 Heli-Expo exhibition in Atlanta, Georgia, on a high note, claiming orders for 43 helicopters from across its civil product range and from all over the world.

Sales recorded at Heli-Expo included an order for 21 helicopters from existing Airbus Helicopters' customer Air Medical Group Holdings (AMGH), comprised of a mix of H125 and H135 aircraft.

Nine of the new helicopters for AMGH had previously been confirmed in 2018 and deliveries are due to occur over three years, beginning in 2019.

AMGH currently operates a fleet of over 80 Airbus helicopters and is part of the Global Medical Response (GMR) transportation company, which boasts 306 helicopters and 100 fixed-wing aircraft.

A further order announced at Heli-Expo, was the selection of the H175 helicopter by the Rescue and Salvage Bureau of the Chinese Ministry of Transport. The organisation has ordered an initial two aircraft, to be configured for search and rescue operations, in a deal announced on March 6, 2019.

Airbus Helicopters also enjoyed success at the single-engine end of the market, with an order for one H125 helicopter from Forest Helicopters Inc of Canada also announced on March 6, 2019.



An artist's impression of an H175 in the colours of China's Rescue and Salvage Bureau of the Chinese Ministry of Transport. The organisation has ordered two such cabs. *Airbus Helicopters*

The helicopter will be acquired via Airbus Helicopters Canada and will be used for a range of operations, including diamond drill support, powerline maintenance, fire suppression, wildlife services, airborne geophysics and precision aerial construction.

The European manufacturer also unveiled a new variant of its popular H145 twin-engine helicopter, fitted with a five-blade main rotor at the event.

Announced on March 4, 2019, the new H145 will be capable of lifting an additional 150kg (331lb) of payload, while allowing an increase in maximum take-off weight to 3,800kg (8,377lb).

European Aviation Safety Agency certification is planned to occur in early 2020, with first deliveries later in that year.

Swiss Air-Rescue Rega became the launch customer for the new variant on March 5,

2019, with a decision to retrofit its fleet of seven H145s to the five-bladed configuration. Six of the seven helicopters have already been delivered, with the final aircraft due to be handed over in May 2019.

Also, on March 5, 2019, Airbus Helicopters announced that the Ukrainian Ministry of Interior has amended its order for eight of out of ten H145s to take advantage of the new variant. *Nigel Pittaway*

Victoria Police AW139s



An artist's impression of an AW139 in the colours of the Victoria Police Air Wing. The organisation will receive three such cabs. *Leonardo Helicopters*

LEONARDO HELICOPTER announced at the Avalon Airshow on February 26, 2019, that StarFlight Victoria has placed a firm order for three AW139 helicopters, to be operated by the Victoria Police Air Wing.

The helicopters will be built by Leonardo in Italy and delivered in late 2019 with entry into service to follow in 2020, following the installation of mission equipment.

In service with the Air Wing,

the AW139s will be equipped with an advanced mission console, camera, a wire cutter system and a rescue hoist.

The selection of the AW139 was previously announced by the Victoria Police Air Wing on October 23, 2018, covering the lease of the three helicopters from StarFlight Victoria, together with a Beechcraft King Air 350ER from Skytraders, as part of its fleet modernisation strategy.

Nigel Pittaway

ACH announces Australia-Pacific customers

AUSTRALIA'S MICROFLITE has become the launch customer for Airbus Corporate Helicopters (ACH) in the Australia-Pacific region, with an order for one ACH135.

Announced at the 2019 Australian International Airshow at Avalon on February 25, 2019, the helicopter was due to be delivered in March 2019.

The ACH135 will be used for a range of VIP and luxury charters in Australia.

Frederic Lemos, Head of Airbus Corporate Helicopters, said: "Microflite has been our customer since 2000, flying a wide range of our light single and twin helicopters. We are honoured by their decision to acquire a new ACH135 for their expanding fleet, becoming our launch customer for this region."

New Zealand's Advanced flight became the second ACH

customer in the region and the launch customer for the ACH145 with an order for one aircraft.

The order, announced at the Heli-Expo exhibition in Atlanta, Georgia, on March 5, 2019 and will be delivered in mid-2020. The ACH145 will be the new version of the helicopter, unveiled at Heli-Expo and will be fitted with a five-blade main rotor.

In other Australia-Pacific news Airbus Helicopters has announced that Pacific Crown Helicopters and John Cameron Aviation will become Maintenance Repair and Overhaul (MRO) partners for the civil production line.

With the announcement at Avalon on February 28, 2019, the two Australian companies will join New Zealand's Airwork NZ and Heli-Support NZ in Airbus Helicopters' regional support network. *Nigel Pittaway*

Dassault acquisitions

DASSAULT AVIATION announced on February 21, 2019, that it has agreed to acquire the Asia-Pacific maintenance, repair and overhaul (MRO) operations of the ExecuJet Group, which provides product support throughout the Asia-Pacific, Middle East, African and European regions, including four locations in Australia and New Zealand alone.

Dassault Aviation President and Chief Executive Officer, Eric Trappier, said: "ExecuJet has earned a solid reputation over three decades for providing state-of-the-art maintenance services to operators throughout Australia and the broader Asia-Pacific region – services that are accessible to business jet owners of all types."

He added: "By retaining the team's separate identity and leadership, and adding invaluable synergies from the Dassault Group, we intend to make significantly enhanced service capabilities available to business jet operators here and around the world."

On February 27, 2019, the company also announced it has acquired the European maintenance activities of TAG Aviation Group.

Trappier added: "The acquisition of the maintenance activities of TAG Aviation, a major MRO provider, will allow Dassault Aviation to reinforce its European service centre network. With TAG Maintenance Services, we intend to develop further a network of excellence and to support TAG's different aircraft clients with the same commitment to service quality, while expanding the share of Falcon maintenance activities controlled by the Dassault Group."

Dassault had two of its business aircraft, the flagship Falcon 8X and a Falcon 2000, registered to Falcon Jet Operations in Australia, on display at the 2019 Avalon International Airshow in February.

Nigel Pittaway

Phenom 300E in Australia



Special Mining Services will use the Phenom 300E VH-UYX on domestic and international charter operations. Embraer

BRAZILIAN MANUFACTURER Embraer announced on February 15, 2019, that it has sold a Phenom 300E to Special Mining Services Pty Ltd in Australia.

The aircraft is the second Phenom 300E delivered in Australia within twelve months.

Special Mining Services owner Andrew Charlton said the aircraft will be operated by Flight Options (Australia) Pty Ltd and will be available for both domestic and international charter operations once approval has been obtained

from Australia's Civil Aviation Safety Authority (CASA). The aircraft will be based at Sydney Airport.

Charlton said: "We chose the Phenom 300E for its ruggedness and ability to take off and land on short runways and this is especially useful for the business we are in. At the same time, its generous cabin space and advanced avionics make it a dream to fly."

He added: "During our journey from Embraer's facility in Melbourne, Florida, to Sydney, we experienced the full spectrum of the aircraft's

performance and we are extremely satisfied with what we have bought,"

According to Embraer, there are nine of its business jets, across four different models, currently operating in Australia, and in the wider Asia-Pacific and China region there are more than 90 of its aircraft operating across over ten countries.

Phenom 300E VH-NSQ operated by Northern Escape, the first Australian customer, formed part of Embraer's static line-up at the 2019 Australian International Airshow at Avalon in February 2019. Nigel Pittaway

Global 7500: endurance records



A Global 7500 recently flew the 8,152 nautical mile trip from Singapore to Arizona non-stop. Bombardier

BOMBARDIER HAS flown its flagship Global 7500 aircraft between Singapore and Tucson, Arizona, claiming a record for the longest-range business jet flight in history operated by a purpose-built aircraft. In addition, the company says it sets a record for the highest speed over the longest distance.

Bombardier announced the achievement on March 4, 2019 and it says the aircraft flew the 8,152nm (15,100km) flight non-stop.

The Global 7500 departed Singapore's Changi Airport at 7:12 local time and arrived at Tucson International Airport at 8:19 local time, which Bombardier claims is a long-range speed record for the city pair.

David Coleal, President of Bombardier Business Aircraft, said: "The Global 7500 aircraft was built to break all the records. It achieved the industry's longest mission ever in business aviation after only two months in service. We've demonstrated its unequalled long-range and high-speed capabilities, but also its ability to break records confidently and with healthy fuel reserves remaining."

Bombardier said the aircraft landed at Tucson International with 4,300lb (950kg) of fuel remaining, a sufficient amount for almost 1.5 hours of additional flight time and "well above" National Business Aviation Association (NBAA) requirements.

The manufacturer also said that the first aircraft to be delivered to a

customer (in December 2018) has already completed 170 hours of flight operations in flights all over the world.

Bombardier brochure figures for the Global 7500 indicate a range of 7,700 nautical miles (14,260km) and a top speed of Mach 0.925.

In related news, the company announced on February 26, 2019, that it will expand its Singapore Service Centre at Seletar, quadrupling its local footprint, from the current 100,000 square feet (9,260 square metres) to 430,000 square feet (40,000 square metres).

The facility will offer training, sales, customer support and maintenance and overhaul facilities and is due to become operational in 2020. Nigel Pittaway

THE ANNOUNCEMENT by Airbus recently that it will end production of its flagship A380 in 2021 was unsurprising.

Sales of the company's super jumbo have struggled for years. Airbus' latest orders and deliveries figures, updated in March to account for cancellations, show it sold only 290 examples of the A380 after the type's formal industrial launch back in December 2000, with the last new firm order placed in 2013 by Emirates. The declining backlog forced the manufacturer to scale back production rates in the last few years from the high of 30 aircraft in 2014 down to eight this year.

This didn't mean axing the aircraft was any less difficult, as Airbus' outgoing Chief Executive Officer Tom Enders (succeeded in April 2019 by Guillaume Faury) reflected: "It was painful to take the decision after all the effort, money and sweat our employees have poured into that programme, but we have to base our decisions on facts."

The most important of those facts is that the A380's quad-jet economics were more expensive than those of the efficient widebody twin-jets such as the Boeing 777 and the A380's own Airbus stablemate, the A350.

The A380 will of course remain a presence in the skies for years to come; Emirates plans to continue flying the type well into the 2030s and Airbus will continue to support the in-service fleet.

Even so, the axe falling on the A380 as a current-production aircraft marks a line in the sand in the history of commercial air transport. The A380 will probably be the last large passenger airliner with four engines.

As the airline industry commentator John Strickland of JLS Consulting reflected to AIR International: "The capability of aircraft to fly long range on two engines unfortunately means the days of four-engine aircraft are coming to a close in terms of new orders. Twins are the way airlines are going."

Boeing still offers the 747-8 Intercontinental, the passenger version of the 747-8, but sales of that aircraft have been even weaker than the A380, with just 47 sold since its launch in 2005. Boeing has for years now said the 747-8's future is tied to air cargo; it has sold 107 examples of the 747-8 Freighter variant so far.

Strickland believes there is logic to the A380 if used to its maximum potential of about 800 seats, which, he said, "would give you a very low cost per seat". However, no airline has ever used an A380 to that maximum capacity – the nearest is Emirates configuring a subset of its fleet with 615 seats – because, ultimately, there are only so many routes where that amount of capacity is required.

Strickland explained Emirates has been able to operate so many A380s (the carrier had 109 in service as of March 2019, with just 14 more to be delivered before A380 production ends), because, "they've built a hub where they've got Airbuses connecting Airbuses,

500 seats feeding another 500 seats, which is a logical nature of [passenger] feed".

For much of the market, however, a platform of the A380's size is simply too big for the demand on most of their routes and, even if A380-sized seat capacity is required, most operators only need it to a limited extent. It is a telling statistic that most A380 operators only have small fleets of the super jumbo compared to the fleet sizes of their other widebody aircraft. British Airways, for example, operating only 12 A380s compared to 58 777s.

With Emirates so instrumental to the A380's commercial prospects, it was clear the Gulf carrier would be decisive in the aircraft's long-term destiny. The airline signed an agreement early in 2018 to buy more examples, but with the airline reportedly unsatisfied with the performance of the Trent 900, it subsequently revised its plans, deciding instead to reduce its outstanding super jumbo backlog by 39 aircraft to 123 and order 40

Quads to twins



The Airbus A380 will not be built after 2021, with efficient twin-jets such as the A350 and 777 having usurped the aircraft.

P Pigeyre/Airbus

A330-900s and 30 A350-900s.

Emirates' decision, combined with a lack of new orders from other customers, little interest from lessors and cancellations (Hong Kong Airlines and Virgin Atlantic were among those to scrap purchase plans, while Air France and Qantas cancelled repeat buys), all led to a sadly inevitable conclusion.

However, the A380's demise as a current-production aircraft is not quite an end of days for large passenger airliners. A new generation of giants is on its way, led by the initial Boeing 777X.

The 777-9, the first version in the updated Triple Seven range, is the largest commercial twin-jet yet developed. Although it doesn't quite match the size of the sole giant Antonov An-225 Myria, which with its 84m (275ft 7in) length and 88.4m-wide (290ft) wings, is the largest commercial aircraft ever developed, the new Triple Seven will still catch the eye.

It will have a very long fuselage (251ft 9in/76.7m), very wide wings

(235ft 5in/71.8m when the folding tips are fully extended for flight) and very large engines (General Electric GE9X turbofans with a 134in/3.4m fan diameter), making it the largest airliner Boeing has ever produced. The 777-9 will be followed by a longer-range variant, the 777-8.

More larger twins could be on the way. Both Boeing and Airbus have already said higher-capacity variants of their big twin families, dubbed the 777-10X and A350-2000 respectively, are technically feasible. The 2020s could well see these larger, longer aircraft developed and enter service.

To casual observers, twin-jets probably have less character than the quads. However, large commercial aircraft still have their place in air transport to cater for high-capacity requirements, even if – as the A380 has shown – this is a limited requirement.

If anything, with the A380 dropping out of the market there is now added potency to the contest between Airbus and Boeing's big twins. Mark Broadbent

Etihad changes



Boeing

ETIHAD AIRWAYS has restructured its orders for Boeing and Airbus aircraft, with the Gulf carrier now committed to taking far fewer new jets than previously planned.

The carrier has revised its commitments to just 20 Airbus A350-1000s, six Boeing 777-9s, an undisclosed number of 787s and 26 A321neos, media reports in the Middle East say.

These numbers compare to previous order announcements from the airline for 62 A350s, 26 777s, 52 787s and 36 A320neo family aircraft.

The airline's Chief Executive

Officer Tony Douglas told IATA early in March about the order changes. He said airlines have to be, "ready to make fast decisions and to adapt at very short notice. This is the new reality, and you will see more and more major players who compete in the global market having to change or alter their operating model."

Douglas said Etihad would optimise its network and rationalise its fleet by phasing out older types. Douglas also said Etihad has been "seen exclusively as an uber-luxury airline" and is evolving into what he called a "fully inclusive full-service airline". Mark Broadbent

Farnborough public days axed



F Lancelotti/Airbus

THE PUBLIC weekend of the Farnborough Airshow has been scrapped, with the famous aerospace event now reduced in size from seven to five days.

In early March, organiser Farnborough International Ltd said the next edition of the biennial event in July 2020 would not have a two-day public weekend, the traditional end to the show following five trade days.

The public weekend has attracted criticism from enthusiasts in recent years because many of the new aircraft in attendance during the trade days leave the show ahead of

the public days, leaving a sparse flying display; at last year's event, some aircraft displayed twice during the day to fill the gaps.

Farnborough International said there will instead be public access on the Friday, including to the exhibition halls, which it said will better highlight new technology and manufacturing to the public and encourage aerospace careers in young people. The Friday event was promoted in 2018 as a Futures Day.

The organiser added there will be a flying display on each of the five days of the 2020 show.

Mark Broadbent

Shockwave

THE IMAGE you see on this page is one of the first ever pictures of the interaction between shockwaves from two supersonic aircraft in flight.

It was captured by NASA's Armstrong Flight Research Center during the fourth phase of the agency's Air-to-Air Background Oriented Schlieren (AirBOS) flights from Edwards Air Force Base, California.

The flights were testing out advanced camera equipment capable of capturing high-quality images of the rapid pressure changes produced when an aircraft flies at supersonic speeds.

The equipment will be used in the forthcoming Low-Boom Flight Demonstration, which will use the X-59 QuEST (Quiet Supersonic Transport) demonstrator currently under development to gather data about the nature of supersonic booms and inform future decision-making about the regulations governing overland commercial supersonic flight.

The images from the AirBOS flights, released by NASA in March, show a pair of T-38s

from the US Air Force Test Pilot School at Edwards Air Force Base flying in formation approximately 30ft (9m) away from each other, with the trailing aircraft flying about 10ft (3m) lower than the leading jet.

A NASA statement said: "With exceptional clarity, the flow of the shockwaves from both aircraft is seen, and for the first time the interaction of the shocks can be seen in flight."

Neal Smith, a research engineer with Aerospace Computing Inc at NASA Ames' fluid mechanics laboratory, said: "What's interesting is, if you look at the rear T-38, you see these shocks kind of interact in a curve. This is because the trailing T-38 is flying in the wake of the leading aircraft, so the shocks are going to be shaped differently. This data is really going to help us advance our understanding of how these shocks interact."

Sonic booms are heard as a result of the shockwaves emanating from components such as the nose, wings, engine and tail that are created as an aircraft travels at supersonic

speed. Schlieren photography, which has its origins in the 19th century, is an imaging technique used by NASA for decades in laboratory wind tunnels and, more recently, in flying trials to visualise shockwaves.

The AirBOS phase four flights featured an upgraded version of the airborne Schlieren photography systems previously used, with NASA saying its researchers were able to capture three times the amount of data in the same amount of time.

Dan Banks, senior research engineer at NASA Armstrong, said: "We're seeing a level of physical detail here that I don't think anybody has ever seen before."

"Just looking at the data for the first time, I think things worked out better than we'd imagined. This is a very big step."

The AirBOS system was carried on board NASA's Beech 200 King Air, which flew in a pattern at around 30,000ft while the T-38s passed at supersonic speeds approximately 2,000ft beneath it, the cameras recording at the exact moment the jets came into

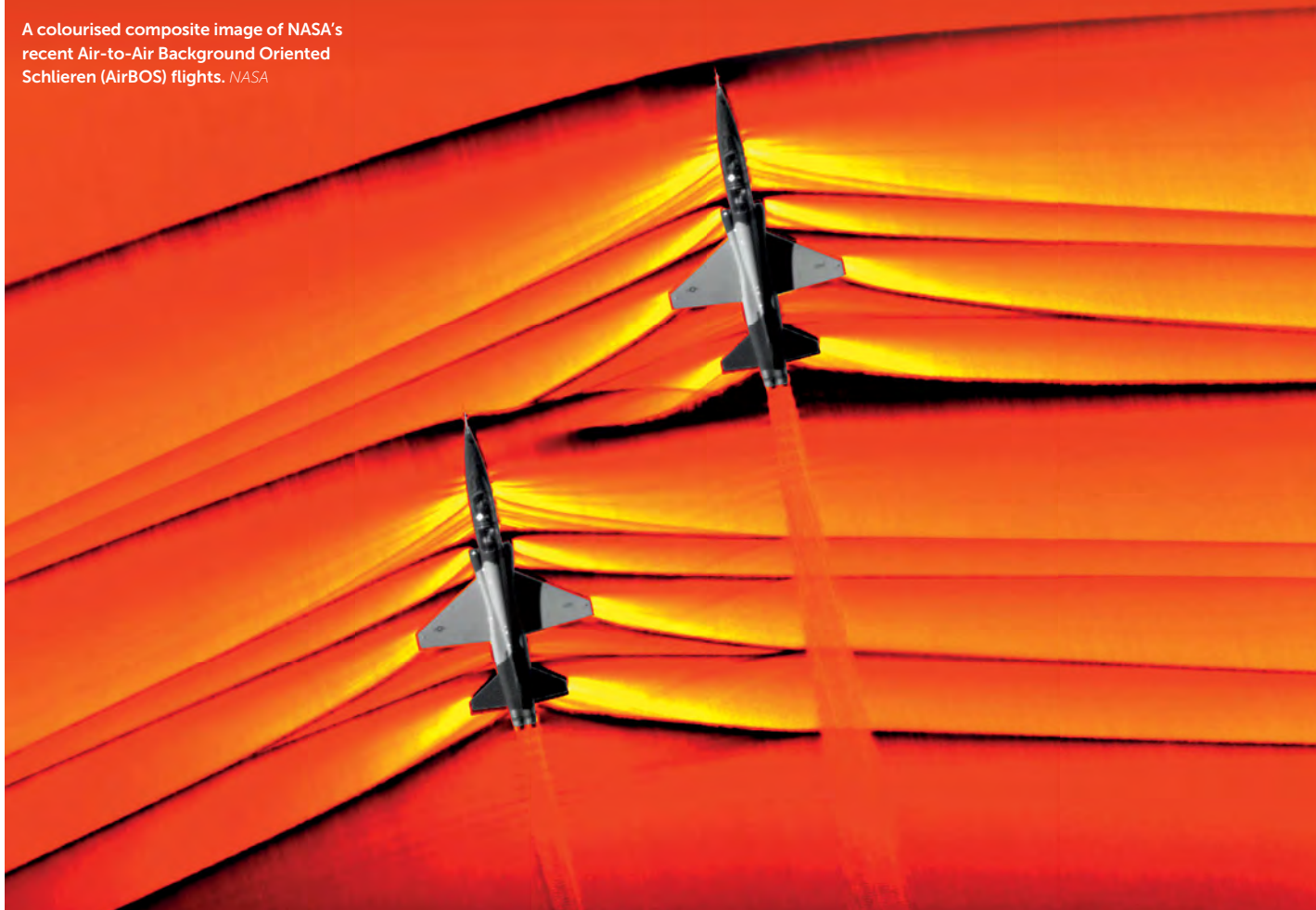
the advanced camera's frame.

The AirBOS system has several important differences from previous Schlieren imaging systems used by NASA. It has a wider field of view, a higher memory capacity (enabling researchers to increase the frame rate to 1,400 frames per second, making it easier to capture a larger number of samples) and an upgraded connection to data storage computers allowing for a much higher data download rate.

The result is more data can be collected, boosting the quality of the images and in turn giving researchers a better understanding about the behaviour of the shockwaves. NASA said the data from the AirBOS flights will continue to undergo analysis, helping it to refine the data-collection techniques and further improve quality of the data.

By understanding in detail how shockwaves behave, more information can be used to develop the X-59 and, in turn, work towards the target of achieving quiet overland supersonic flight. Mark Broadbent

A coloured composite image of NASA's recent Air-to-Air Background Oriented Schlieren (AirBOS) flights. NASA



A dynamic aerial photograph taken from the cockpit of a modern fighter jet, looking out over a large crowd at an air show. In the foreground, the pilot's helmet and oxygen mask are visible. To the left, a vintage Spitfire flies in formation. In the background, a Eurofighter Typhoon is seen performing a maneuver, leaving a long, vibrant purple smoke trail against a blue sky with scattered clouds. The ground below is filled with a vast sea of spectators, tents, and airport infrastructure.

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